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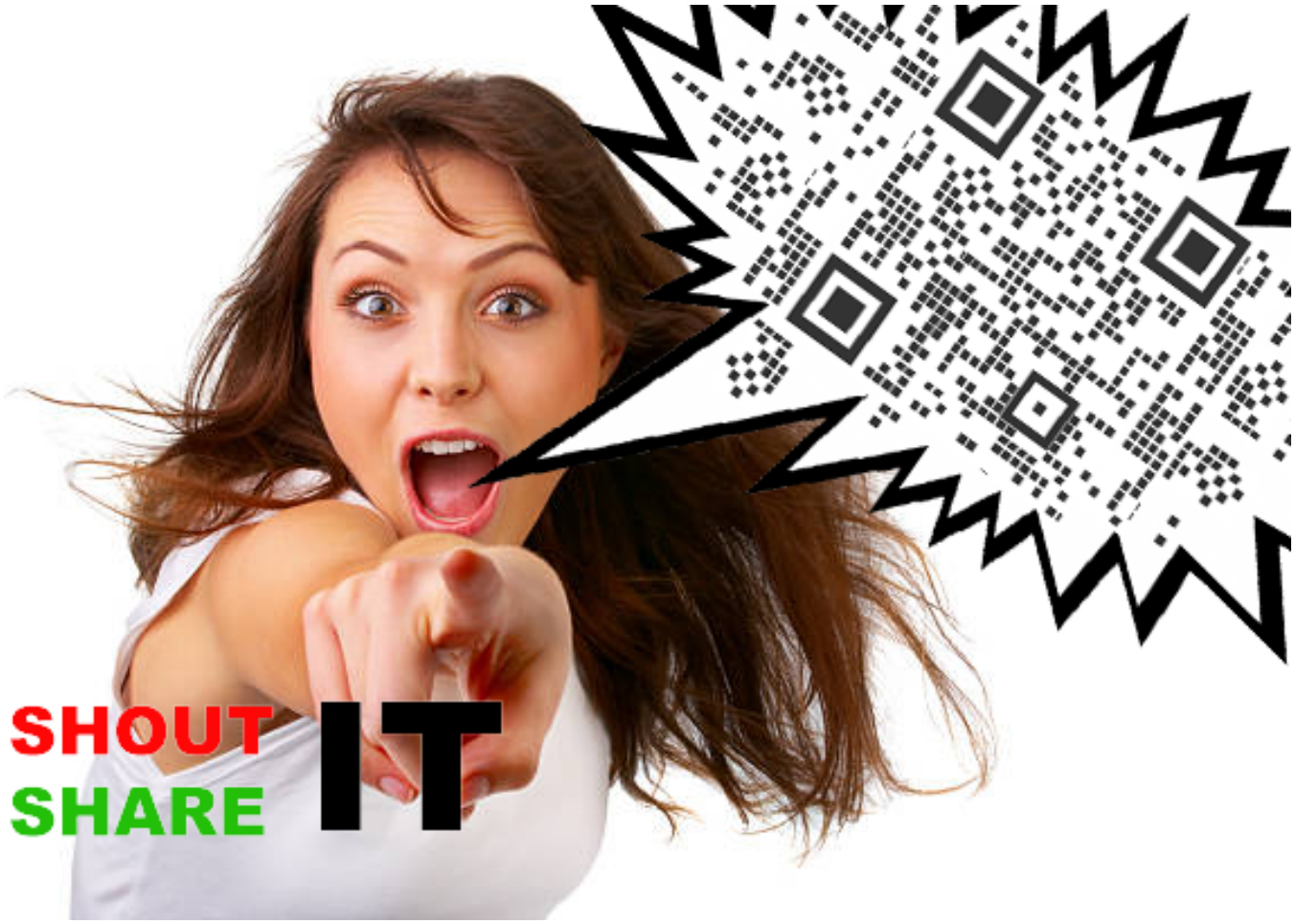
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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 545

Joint Contribution from the Forest Service, HENRY S. GRAVES, Forester
and the Bureau of Plant Industry, WM. A. TAYLOR, Chief

Washington, D. C. PROFESSIONAL PAPER October 8, 1917

IMPORTANT RANGE PLANTS:

THEIR LIFE HISTORY AND FORAGE VALUE

By

ARTHUR W. SAMPSON, Plant Ecologist, Forest Service

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PREFATORY NOTE.

Early in its administration of the National Forests the Forest Service was confronted with the problem of restoring the vegetation on many areas on which the natural ground cover had been completely or partially wiped out by destructive overgrazing before the areas were included in National Forests. In order to secure the fundamental information on which beneficial changes in the practice of grazing on such areas might be based the Forest Service joined the Bureau of Plant Industry in 1907 in a cooperative project of grazing investigations. Several important reports have been published, embodying the results of these various field studies, and the changes that have been made in the administration of grazing on the National Forests in accordance with the results of the investigations have brought about conspicuous improvement in the ground cover, great advance in the protection of watersheds, and important increase in the number and quality of stock grazed. A part of the original plan of investigation was to make a detailed study of the life history of each important grazing plant for the special purpose of determining its reproductive season, from the sending up of the flower stalk to the maturing of the seed, and the period necessary to enable the new seedlings to reach a size and vigor sufficient to withstand moderate trampling by stock. In the course of these studies a very large amount of detailed information about the important grazing plants was acquired which could not be used in the more general reports already published. In the paper now presented for publication a portion of this detailed information is given, in a form suited to the needs of forest officers and of stock owners who desire to familiarize themselves with the habits and requirements of the plants upon which their animals subsist. Such knowledge is necessary to the highest success in their business just as a knowledge of the habits and requirements of cultivated plants is necessary to the highest success in the business of the farmer. For the first time in the history of grazing-plant literature the information needed to accomplish this result has been acquired and presented for public use.

FREDERICK V. COVILLE,
Botanist, Bureau of Plant Industry.

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OBJECT OF THE STUDY.

Although practically all types of grazing lands support a variety of plant species, only a certain proportion of the grasses and of the other plants are important from a grazing standpoint. Some species, owing to their wide distribution and abundance, as well as to the relish with which they are cropped, are valuable forage plants; others because of certain chemical contents either during the entire season or at some period of it are poisonous, and therefore seriously objectionable on the range; while still others, either through some peculiar physical structure or because they contain a superabundance

of tannic acid, which renders them unpalatable are of little or no value for forage.[1]

In order to gain an intimate knowledge of the habits, requirements, and life history of the more important species, a study was initiated in 1907 by the Forest Service, in cooperation with the Bureau of Plant Industry, upon the Wallowa National Forest in northeastern Oregon. Data on the relative palatability of the different forage plants were gathered by following bands of sheep and observing their choice of feed as they grazed. Afterwards the relative value of the individual range plants was determined by studying (1) their abundance, distribution, time of flower-stalk production, aggressiveness, reproduction (both vegetatively and by seed), and seed habits; and (2) their palatability and nutritiousness at various times during the grazing season and their ability to withstand trampling. The plan of study and the methods used are fully described at the end of the bulletin.

While the results of the study are largely based upon observations in the high mountains in Oregon between elevations of 5,500 and 8,000 feet, they should nevertheless be helpful to stockmen throughout the West in revegetating the range, since many of the species described are widely distributed, and the genera represented are among those of first importance on most of the natural range lands of the West.

A photograph of each important species in natural size accompanies its description, but where the general characters of two or more species of the same genus are similar, a single photograph is used. With the exception of Plate XXXVIII all specimens selected for photographic purposes were either in flower or fruit, or both, and care was taken to show the general character of the root system, habit of growth, and external structure. Not only will these photographs make possible, in practically every instance, the recognition of the same species when met with in the field, but also other species of the same genus will be recognized as congeneric, although the specific name may not be known to the observer.

CHARACTER OF THE RANGE AND FORAGE STUDIED.

Between the lower and higher grazing lands of the mountains of northeastern Oregon is a difference in elevation of about 7,000 feet. Along with this wide altitudinal variation go widely different growth conditions. Thus, according to the character of the vegetation, the lands studied may be classified into four zones.[2]

[1] The results of natural revegetation studies based upon observation of the plants described in this bulletin are presented by the writer in U. S. Dept. Agr. Bul. 34, "Range Improvement by Deferred and Rotation Grazing," 1913, and in the Journal of Agricultural Research, Vol. III, No. 2, "Natural Revegetation of Range Lands Based upon Growth Requirements and Life History of the Vegetation," 1914.

[2] Merriam, C. Hart, "Life Zones and Crop Zones of the United States," U. S. Dept. of Agriculture, Biological Survey Bul. No. 10, 1898.

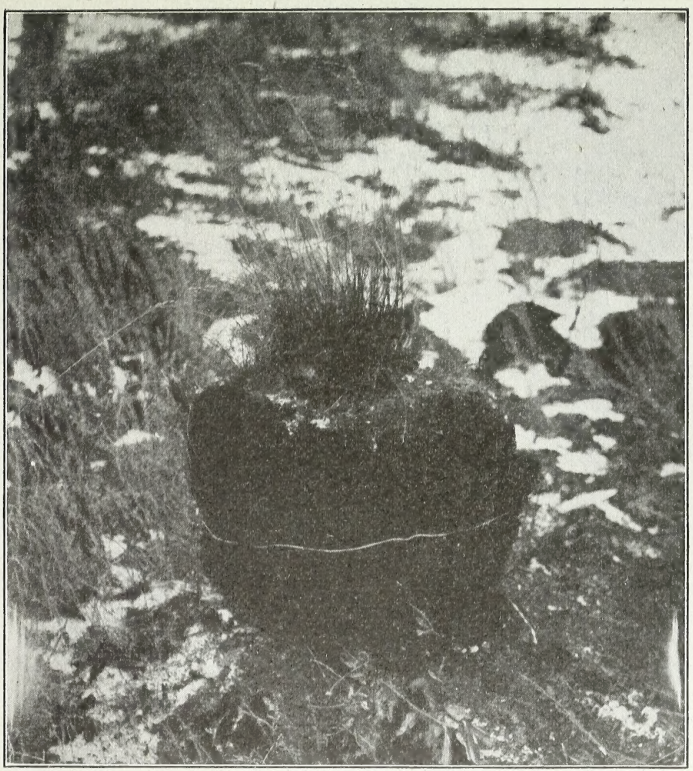

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FIG. 1.—Wire-basket method of drying out the soil surrounding the roots. Portability is the chief advantage of this method.

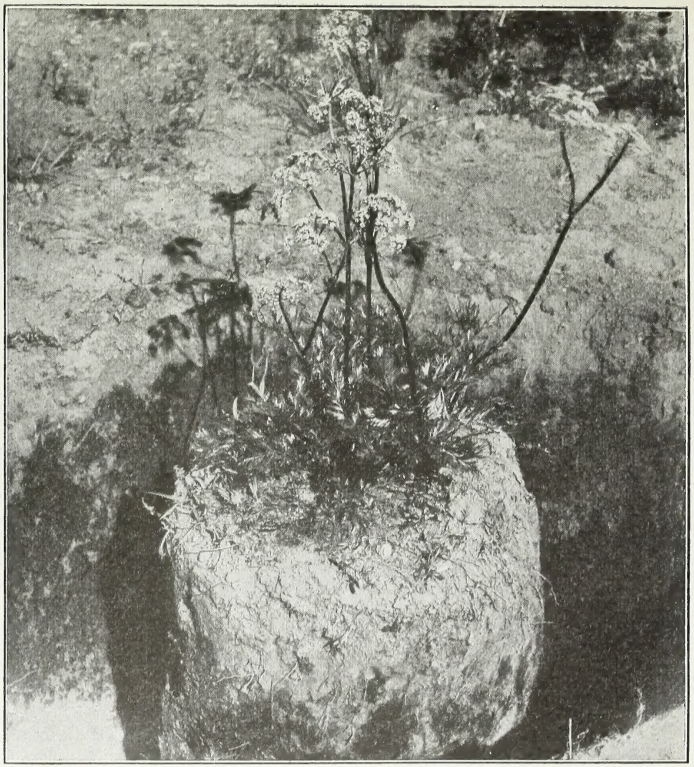

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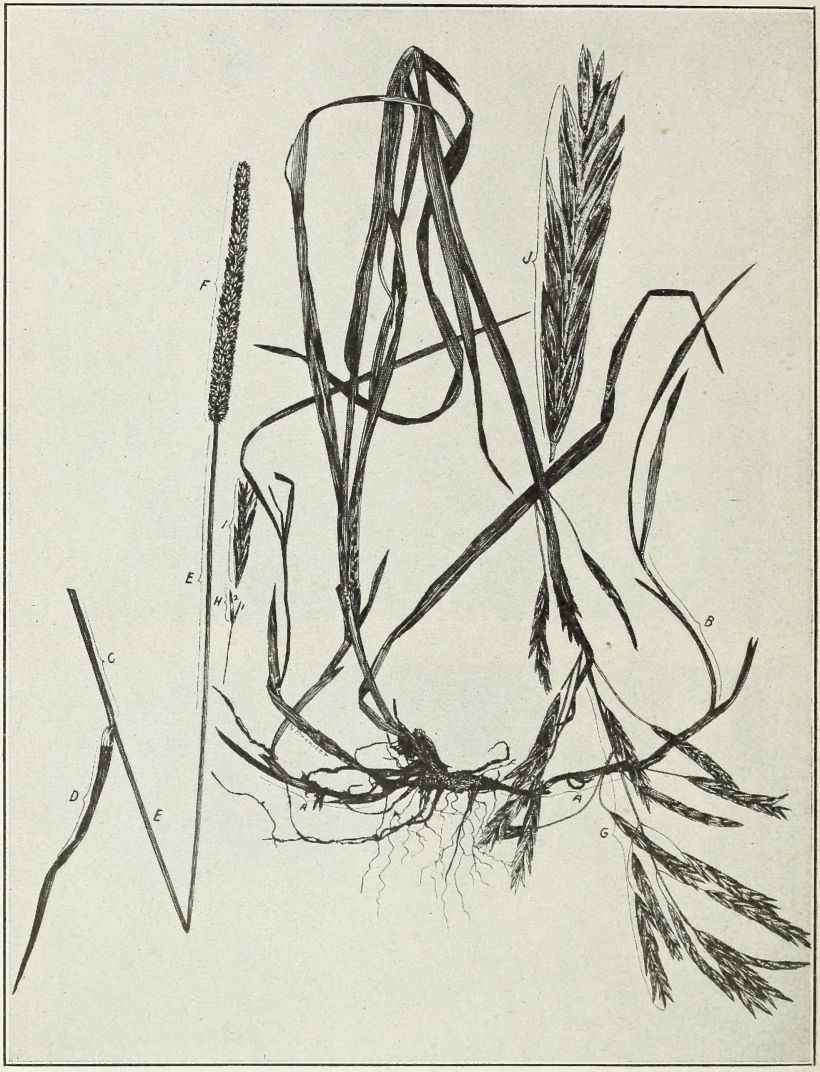
FIG. 2.—The natural-position method. Especially satisfactory in the case of plants with taproots.

METHODS EMPLOYED IN DETERMINING THE WATER REQUIREMENTS. (SEE APPENDIX, P. 61.)



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GENERAL MORPHOLOGY OF GRASSES.

A. Rhizome or rootstock.
B. Shoot from rootstock.
C. Sheath.
D. Blade.
E. Culm.
F. Spikelike panicle of timothy.
G. Open panicle of bromegrass.
H. Glumes or scales—
    (1) First glume.
    (2) Second glume.
I. Florets.
J. Natural size of complete brome spikelet. Plants one-third natural size.

1. A Transition zone or yellow-pine association occupying the country between 3,000 and 4,500 feet elevation.

2. A Canadian zone or lodgepole-pine association between 4,500 and 6,800 feet elevation.

3. A Hudsonian zone or white-bark pine association between 6,500 and 8,500 feet elevation.

4. An Arctic-alpine zone or alpine-meadow association from 8,000 feet elevation up.

Owing to the wide difference in the physical conditions in these zones, numerous rather distinct range types occur. The time during which each is grazed varies according to the location.

The Transition zone (yellow-pine association), owing to the open character of the tree stand, supports a rather dense grass cover. Big bunchgrass (*Agropyron spicatum*) occurs in pure stands on the less elevated lands, and pine grass (*Calamagrostis suksdorfii*), blue bunchgrass (*Festuca idahoensis*), little bluegrass (*Poa sandbergii*), and mountain June grass (*Koeleria cristata*), named in the order of their importance, are the most valuable species at somewhat higher elevations. The majority of the important species are herbaceous. This zone is among the first to be grazed in the spring, the lower lands usually supporting stock early in March. By June 1 the forage in the higher adjoining lands is preferred because of its greater succulence.

The Canadian zone (lodgepole-pine association) is more densely forested than the others. Also the forage, instead of being herbaceous, is mainly shrubby or of the "chaparral" type. The most important browse plants in this zone are fire willow (*Salix nuttallii*), black elder (*Sambucus melanocarpa*), high huckleberry (*Vaccinium membranaceum*), and wax currant (*Ribes cereum*). Since the physical conditions in the Canadian zone are intermediate between those of the Transition zone below and the Hudsonian zone above, few plants are wholly confined to this region, and many of the species of the transition zone are encountered here. The grazing period in the Canadian zone comes approximately between May 15 and July 15.

The Hudsonian zone (white-bark pine association) is characterized by scattered small clumps of woodland and a preponderance of grassland. The most important forage species are mountain bunchgrass (*Festuca viridula*), onion grass (*Melica bella*), porcupine grass (*Stipa occidentalis*), wild celery (*Ligusticum oreganum*), and butterweed (*Senecio triangularis*).

While this region is not suited for early grazing, because of the lateness of the growing season, it has as great an area and carries about as many stock as both of the lower zones together. It includes all the high summer sheep lands, except the few crests that are grazed above timber line. The grazing period begins approximately July 15 and continues through August and September.

The Arctic-alpine zone (alpine-meadow association), owing to its small carrying capacity and inaccessibility, has little or no value for grazing, and the character of its vegetation need not be discussed.

On the Wallowa National Forest the vegetation which furnishes the greater part of the forage is distinctly herbaceous. It consists primarily of grasses, sedges, and rushes, with a fair representation of nongrasslike species commonly termed "weeds." While the species are numerous, about 50 furnish virtually all of the range forage.

GENERAL MORPHOLOGY OF GRASSES.

In the discussion of the individual species it will be necessary to refer to specific characters in a general way as a means of distinguishing one species from another. It is essential, therefore, that the reader have a clear conception of what a true grass is. The stems or culms are usually hollow except at the joints (*nodes*). The leaves consist of two parts, the *sheath*, which surrounds the culm usually like a split tube, and the blade. The minute flowers are arranged in spikelets consisting of a shortened axis (the *rachilla*) and from two to many 2-ranked scales, the lower two of which (the *glumes*) are empty, while each of the others (the *lemmas*) bears in its axil a flower inclosed in a 2-nerved scale (the *palea*). Lemma, palea, and flower, together, are termed the *floret*. The spikelets may be sessile (without a footstalk) along a jointed axis (the rachis), as in wheat and rye, the whole constituting a spike, or on little stems (*pedicels*) and arranged in panicles, as in mountain bunchgrasss and smooth bromegrass. The head of timothy is a panicle with the branches and pedicels greatly shortened. This is called a spikelike panicle. Sometimes the lemmas or the glumes bear bristlelike appendages termed awns. The "beard" of barley consists of awns.

Plate II has been prepared to illustrate characters which will frequently be alluded to in the following discussion. In this illustration cultivated timothy (*Phleum pratense*) and smooth bromegrass (*Bromus inermis*) are used because they are well known to stockmen and because they represent the morphology of two distinct and important tribes of grasses.

IMPORTANT SPECIES.

GRASSES.

The grass family (*Poaceae*) contains about 3,500 known species. They vary in size from small, mosslike individuals in the extreme Polar regions to treelike growths of a hundred feet or more in the Tropics. As a whole, no family of plants enjoys a wider distribution or grows in a greater variety of soils, and no other family is as important economically. From a grazing viewpoint the grasses are more valuable, all localities considered, than all other plants put together.

The general taxonomic characters of grasses are shown in Plate II.

MOUNTAIN BUNCH GRASS (FESTUCA VIRIDULA).

The specimen shown is in process of fertilization. A, glumes; B, lemma; C, palea; D, the caryopsis or grain.

F–40

PORCUPINE GRASS OR NEEDLE GRASS (STIPA OCCIDENTALIS).

The seedling shown is of about the average size attained at the end of the growing season.

KEY TO THE TRIBES AND GENERA.

KEY TO THE TRIBES.

A. Spikelets upon pedicels in open or spikelike panicles, not in rows.
  B. Spikelets with but 1 perfect flower (the rachilla prolonged behind the palea as a bristle in *Calamagrostis* and *Cinna*).....Tribe *Agrostideae*.
  B. Spikelets with 2 or more perfect flowers.
    C. Glumes usually longer than the first floret; florets with bent awn on the back (excepting *Koeleria*).....Tribe *Aveneae*.
    C. Glumes much shorter than the first floret, unawned or with a straight awn from the apex.....Tribe *Festuceae*.
A. Spikelets sessile, in opposite rows along a zigzag jointed rachis forming a spike; leaf blades bearing a pair of earlike appendages at the base.....Tribe *Hordeae*.

KEY TO THE GENERA.

Agrostideae.

A. Lemmas hardened, having a needlelike point at base and a long, usually twice bent awn at the summit.....Genus *Stipa*.
A. Lemmas thin and delicate, not needle-pointed at base, awnless or with a minute awn from the back.
  B. Spikelets in a dense spikelike head; glumes abruptly awn-tipped.
    Genus *Phleum*.
  B. Spikelets in open or narrow panicles; glumes not awn tipped.
    C. Floret raised on a little stalk; spikelets in a large nodding panicle.
      Genus *Cinna*.
    C. Floret sessile.
      D. Floret bearing at base copious white hairs sometimes as long as the lemma; rachilla extended behind the palea.....Genus *Calamagrostis*.
      D. Floret naked or nearly so; rachilla not extended behind the palea, the latter often wanting.....Genus *Agrostis*.

Aveneae.

A. Lemmas awned.
  B. Panicles open; lemmas convex, irregularly toothed or 2-lobed, awns arising from below the middle.....Genus *Deschampsia*.
  B. Panicles narrow or spikelike; lemmas keeled, 2-toothed, the awn arising from above the middle.....Genus *Trisetum*.
A. Lemmas not awned, panicles spikelike, culms pubescent below panicle.
  Genus *Koeleria*.

Festuceae.

A. Spikelets with upper florets usually sterile, broad and folding about each other, forming a club-shaped mass; glumes shining; lemmas papery, scarious margined.
  Genus *Melica*.
A. Spikelets with upper florets not unlike lower ones in shape, but often reduced in size.
  B. Spikelets not over 5 mm. ($\frac{1}{5}$ of an inch) long; not awned.
    C. Lemmas keeled, acute, the nerves not prominent.....Genus *Poa*.
    C. Lemmas convex, obtuse, the nerves prominent.....Genus *Panicularia*.
  B. Spikelets 1 cm. ($\frac{2}{5}$ of an inch) or more long, awned or awn-pointed.
    D. Lemmas 2-toothed, usually awned just below the apex...Genus *Bromus*.
    D. Lemmas entire, usually awned from the tip.....Genus *Festuca*.

Hordeæ.

A. Spikelets solitary at each joint of the rachis.....Genus *Agropyron*.
A. Spikelets 2 or more at each joint of the rachis.
B. Rachis continuous, awns erect, not over 2 cm. (⅘ of an inch) long. Genus *Elymus*.
B. Rachis readily separated into joints, awns spreading, 4 cm. (1⅗ inches) or more long.....Genus *Sitanion*.

Mountain Bunch Grass.

(Festuca viridula.)

The genus *Festuca* is well represented in the United States, about 30 native species being recognized.[1] Most of them are abundant in the regions to which they are adapted, though three species have been collected but once, two others but twice, and another species, *F. rigescens*, has been found but once in North America.

Several North American species of *Festuca* are of great value for forage and hay. Among these, mountain bunch grass, while not as widely distributed as some others, for example, blue bunch grass (*F. idahoensis*), is nevertheless the most valuable for grazing purposes because of its greater palatability and nutritiousness. Next in forage value are blue bunch grass (*F. idahoensis*) and red fescue (*F. rubra*), of the West, and *F. altaica*, an important range plant in Alaska. A number of the annuals are valuable for grazing purposes in the semiarid regions, especially in the foothill areas of the Southwest, where the seed germinates late in the fall and growth continues through the winter. Under such conditions they often furnish a first-class palatable forage at a time when nothing else is available.

While mountain bunch grass is usually abundant in the localities in which it occurs, it has not a very wide distribution. Its natural home is in the Hudsonian zone, where it occurs from the lower to the higher limits, reaching well up to timber line. Wherever found in the United States it is closely restricted to the higher elevations. On the Wallowa National Forest in northeastern Oregon, it is seldom found below 6,500 feet. Of all the specimens examined in the National Herbarium the lowest altitude reported was 5,000 feet.

While stockmen usually recognize the species when they see it, and appreciate its forage value, it is sometimes confused with other grasses, perhaps most commonly with blue bunch grass (*F. idahoensis*). The latter, however, is distinctly a plant of the Transition zone and is seldom found where mountain bunch grass abounds. The rather prominent awns and the "bloom" on the leaves, which gives the characteristic bluish tinge, readily distinguish blue bunch grass from *F. viridula*.

[1] Piper, Contr. U. S. Nat. Herb., Vol. 10, p. 1, 1906.

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LITTLE NEEDLE GRASS (STIPA MINOR).

F-60

MOUNTAIN TIMOTHY (PHLEUM ALPINUM).

Mountain bunch grass (Plate III) forms densely tufted hummocks or bunches. It has coarse, deep, and spreading perennial roots; erect, slender, and smooth culms from 1 to 2 feet high, slightly thickened at the base; a preponderance of rather long inwardly rolled (involute), smooth or somewhat rough basal leaves; and open semi-nodding panicles, composed of rather compressed spikelets, often of a dark purple color, bearing 3 to 6 florets.

As indicated by its usual habitat, mountain bunch grass stands near the head of the list in drought-resistant qualities. Well established plants subjected to the gradual drying process began wilting excessively when the water content was reduced to 9.5 per cent, and did not, as a rule, recover after the per cent of water dropped to 7. Such a low amount of water about the main roots would be very unusual, of course, on the high range, but it shows the possibilities of mountain bunch grass in dry situations.

Observations during 1907, 1908, and 1909 showed that the flower stalks were sent up from July 5 to August 20, July 10 to August 25, and July 3 to August 15 in the respective years. The seed crop for these seasons began to ripen as early as August 5, and by September 5 practically the entire crop had matured. The seeds are disseminated almost immediately upon reaching maturity. Flower-stalk production and seed maturity occur earlier upon coarser, less decomposed soils, where the soil water is readily reduced through evaporation and where the temperature in the substratum is relatively high.

Mountain bunch grass seed has a low viability. The average for all laboratory tests made during the three seasons was 12.2 per cent. Field tests in the natural habitat, with seed from the same source, gave a much higher percentage of germination.

Upon the higher ranges mountain bunch grass is grazed ravenously by all classes of stock. It is most highly relished at the time of flower-stalk production, the entire aerial portion, including the succulent leaves and the flower stalks, often being removed at that time by a single grazing. As the season advances, sheep discriminate between the leaf blades and culms, and when the plant has matured its seeds the latter are rarely cropped. Ripening of the seed crop, however, impairs the plant's palatability and nutritiousness but little. As a rule, the leaf blades are not eaten so closely as earlier in the season, and the fibrous stems or seed stalks remain untouched. But little else of the forage is wasted.

The nutritive value of mountain bunch grass is indicated in Table 1, which also presents an analysis of well cured timothy hay for comparison.

TABLE 1.—*Chemical analysis of mountain bunch grass and timothy hay.*

Material.	Protein (nitrogen).	Ether extract (fat).	Crude fiber.
Mountain bunch grass:			
Matured plant	13.18	2.83	22.20
Growing plant	12.24	3.60	21.15
Matured flower stalks	4.18	1.30	38.65
Timothy hay	6.78	2.87	33.40

It will be seen that there is comparatively little difference in the nutritiousness of mountain bunch grass at the time the flower stalks are being produced and immediately after the seed crop has ripened. The greatest difference in the important constituents is found in the ether extract (fat), which is 27.21 per cent greater in the younger plants. This is partly offset by the fact that there is 7.68 per cent more protein (muscle making nutrients) in the matured plants. The latter also contain 4.96 per cent more crude fiber than the young plants, the most indigestible portion of the forage. In the matured flower stalks the protein (nitrogen) and the ether extract (fat) are very low, while the indigestible (crude fiber) material is very high. This fact explains in part why the flower stalks are not grazed at maturity.

Investigations have shown that well-cured grasses yield as much nutriment as the same grasses when green.[1] There is this distinction, however, that ordinarily the cured forage is not as palatable as the green. But since about half of the basal leaf blades remain green until the end of the grazing season, the palatability and nutritive qualities of mountain bunch grass remain comparatively high after seed maturity.

A plant closely related to the one discussed is blue bunch grass (*F. idahoensis*). Being confined almost entirely to lands of medium elevation, and the herbage having a distinctly bluish color and the awns on the culms and lemmas being about twice the length of those of mountain bunch grass, the two are readily distinguished even though both are distinctly bunch grasses.

The flower stalks of blue bunch grass begin to show about the first week in June in the typical (yellow-pine) habitat and they continue to be produced until about August 1. The seed matures, for the most part, between June 25 and August 15. The seed tested for germination show a viability of from 11 to 21 per cent.

Blue bunch grass furnishes excellent forage for all classes of stock from early spring until the early part of August, when it begins to mature and the leaf blades become somewhat tough and dry. Even at that time it is grazed to a greater or less extent by cattle and horses, but only to a limited extent by sheep. All stock, however, relish

[1] Wolff, E., Farm Foods, 1896, English edition, p. 155.

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SLENDER REED-GRASS (CINNA LATIFOLIA).

F-80

ALPINE REDTOP (AGROSTIS ROSSAE).

blue bunch grass in the autumn on account of the new growth resulting from the autumn precipitation. As a whole, it is a palatable and nutritious grass, and, occuring as it does in abundance over well-drained lands of medium elevation, its economic value is high.

Porcupine Grass.

(*Stipa occidentalis.*)

The genus *Stipa* includes a large number of perennial grasses distributed throughout the world. Approximately 30 species are found in the United States, mainly in the West. Many are valuable for grazing purposes, while others are cut for hay.

Porcupine grass (Plate IV) is a perennial bunchgrass with coarse, spreading, and deeply penetrating roots, capable of withstanding an unusual amount of abuse. The leaf blades are mainly basal, somewhat involute (rolled inward), those of the culms shorter than the basal ones, all rather rough and somewhat rigid, the sheaths shorter than the internodes. The panicle is somewhat contracted, about 4 inches long; the spikelets one-flowered; the floret cylindrical, pubescent throughout, with a sharp-pointed bent callus at the base. The empty glumes are subequal, membranaceous, and the lemmas or flowering glumes, which completely inclose the palets, are brownish when mature and bear awns from 1 to 1½ inches long, twice bent and strikingly plumose or densely pubescent to the second joint or knee.

To judge from the tufted habit of growth and the involute leaf blades and their texture, it might be expected that the moisture requirements of porcupine grass would be about the minimum of the species studied. An average of all moisture tests, however, showed that pronounced wilting resulted in the characteristic soil type where the water content varied from 9.5 to 11.5 per cent. In a soil containing 8 per cent of moisture a specimen failed to recover its form and subsequently died. Fearing that some error had crept into the results first obtained, several additional tests were conducted, but the later results agreed with the first.

Porcupine grass inhabits only well-drained soils in open, exposed situations in association with mountain bunchgrass, alpine redtop, short-awned bromegrass, and other species. Its seedlings develop somewhat deeper roots than do the majority of the species, and because of this fact they have thrived during dry periods in certain places where other species able to exist in soil of slightly lower water content have died.

The flower stalks are all produced within a month or less after the first ones appear. They begin to show about July 15. The seeds are, as a rule, well matured by September 10. In 1909, however, they had ripened and were disseminated by August 30. Dissemination follows almost immediately upon maturity.

The seed crop has a fair viability, the average for the three years being 27 per cent. The highest germination, obtained in 1909, was 35 per cent. On the range this species is reproducing so abundantly that it is very probable that a much higher viability results when the seed is allowed to pass through the usual conditions after maturing. The seed, too, has an effective means of getting into the ground through the boring action of the awn, and this may account largely for the plant's rapid invasion of many situations. It is among the most promising species for restocking depleted ranges.

Although not to be compared with mountain bunchgrass in palatability, porcupine grass is a good forage plant. It begins growth early in the season and continues growing until late in the summer, the leaf blades remaining green until September 1. Although their texture is somewhat harsh and their edges slightly scabrous, the plant is grazed with considerable relish by sheep, cattle, and horses, though considered most desirable for sheep. Both cattle and horses eat the flower stalks, even when the seeds are approaching maturity, and the long, rather bristlelike awns are likely to make sore mouths or even to cause serious trouble in the throat, sometimes resulting in what is termed "temporary lump jaw." Other grasses, however, may be more directly responsible for these bad effects. Sheep do not consume the flower or seed stalks, but graze the leaf blades closely.

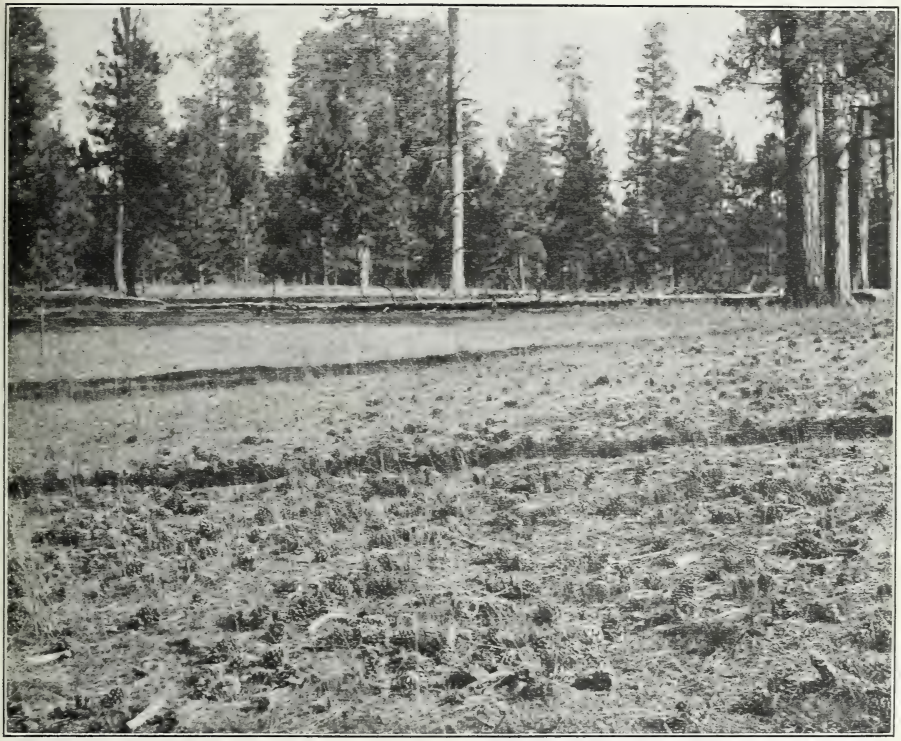
A species closely allied to porcupine grass is little needle grass (*S. minor*). It is very similar in general characters, ecological requirements, and distribution, and for that reason will not be discussed in detail here. While as widely distributed as *S. occidentalis*, it is not nearly so abundant. The plant is taller and may be distinguished at a glance by observing the awns, which are less than half the length of those of *S. occidentalis*, and which, instead of being plumose, are very slightly pubescent or merely roughened. Because of its sparse growth, the plant is not especially valuable for grazing, though eaten with relish by most classes of stock. (See Plate V.)

Mountain Timothy.

(*Phleum alpinum.*)

The genus *Phleum* contains about 10 annual and perennial species, most of which are confined to the Temperate and Arctic regions. Among them is the cultivated timothy, generally conceded to be the most valuable forage and hay plant in the United States.

Mountain timothy is occasionally mistaken for the cultivated timothy. While the two plants have somewhat the same general appearance (compare Plates II and VI), the cultivated species, *P. pratense*, usually grows from 2 to 4 feet high, while mountain timothy as a rule attains less than half that height; also the spike of the latter,



F–9Q

VIEW SHOWING HOW CLOSELY SHEEP GRAZE PINE GRASS IN THE SPRING OF THE YEAR.

The fibrous woody roots and the fact that it forms a turf renders it almost proof against trampling and close grazing. Pine grass is one of the hardiest and most prolific grazing plants in the Wallowa Mountains.

F-10G

PINE GRASS (CALAMAGROSTIS SUKSDORFII).

On the right is shown a pine-grass seedling of 2 months' growth.

about 1 inch long, instead of being cylindrical and having short awns on the glumes like the cultivated species, is ellipsoid or ovate-oblong, the awns about the length of the glumes.

Like the cultivated species, mountain timothy is a perennial plant and has the sheaths of the upper portion of the leafy culms loose as compared with the lower ones. The spikelike panicle is usually purple in color, and the glumes of the spikelets are slightly fringed on the back.

Mountain timothy is confined to alpine and subalpine regions. In the region studied it is closely restricted to the Hudsonian zone. It is a plant of turfy habit, growing in moist meadows and swales, around springs, and along banks of streams. Often the stands are dense and pure. In some places, however, the keenest competition exists between the mountain timothy and certain sedges and rushes, the result being that one species predominates here and another there. Since it grows characteristically in boggy or nearly saturated soils, mountain timothy wilts beyond recovery even though there may be a rather high percentage of moisture in the substratum. The five specimens tested for drought resistance persisted only until the water content was decreased to an average of 14 per cent.

The flower stalks are produced later than those of vegetation in drier situations, since the moister soils are slower in warming up in the spring. Usually the stalks begin to appear about July 15, and are all produced by the end of the first week in August. Mature seeds can generally be found after August 15, and continue to ripen until about the middle of September.

The fertility of the seed crop is considerably above the average for a typical subalpine herbaceous plant. The average per cent for all tests was 69.5, the maximum germination of 76 being obtained in 1909 and the minimum of 58.2 in 1907.

When compared with the average marsh or bog species, mountain timothy ranks high as a forage plant. Early in the summer it is considered by stockmen to be a bit too succulent or "washy," but since sheep naturally avoid its habitat, which is invariably moist at that season, there is little demand for it then. As the season advances, however, the soil becomes drier, and the latter part of the summer this grass is grazed with relish. Mountain timothy remains green and tender unusually late in the fall, and, compared with other species grazed at that time of the year, it is eaten with unusual relish.

Slender Reed-Grass.

(*Cinna latifolia.*)

The genus *Cinna* is represented by but three species in the United States. Of these, slender reed-grass (*Cinna latifolia*) is the most important in the localities studied.

Slender reed-grass is a rank growing perennial from 1½ to 4 feet tall. The culms, which are usually very brittle, are bent like a knee at the lower joints. Like the sheaths, the leaf blades are rough, and are especially broad and very flat (Plate VII). The panicle is long, often exceeding 8 inches, open, and usually drooping.

The favorite habitat of slender reed-grass is in sparsely vegetated forests which admit enough light for the undergrowth to succeed. It is closely restricted to shaded situations with well-watered soils.

The inherent tendency toward shade is shown by the unusually wide and flat leaf blades as well as the absence of basal leaves, while the high water requirements are shown, among other things, by the meager development of the root system, the absence of special contrivances to retard transpiration, and the restriction of the species to wet soils. Growing in situations very similar to mountain timothy, it has virtually the same water requirements. Failure to recover from wilting took place in the mucky soil in which this species grows when the moisture content in the case of one specimen was 13.5 per cent and in another 16 per cent.

The flower stalks were produced from July 5 to August 5, July 10 to August 15, and from July 5 to August 10 in 1907, 1908, and 1909, respectively. Compared with the earliest appearance of the flower stalks, the seed reached maturity at a relatively late date, the earliest being about the last week in August. The crop matured evenly, however, with approximately 15 days intervening between the time the earliest seed matured and the major portion ripened.

The length of time required for a seed crop to ripen in nearly all cases seems to influence the vitality of the resulting crop. An even and comparatively short maturing period usually indicates, for a given locality, seed of higher vitality than that which ripens at wholly different dates. The average germination of the seed crop of slender reed-grass for the three seasons was 86.8, and the minimum yearly average, 79 per cent, obtained in 1907.

Since slender reed-grass does not enjoy an especially wide zonal distribution, and is closely restricted to moist situations, it supplies but limited forage. So far as palatability is concerned, however, it ranks high, and since it remains green and tender throughout nearly the entire summer grazing season, the herbage is closely consumed. Owing to the moist condition of its habitat in the early part of the season, the plant is seldom grazed by sheep until August.

Alpine Redtop.

(*Agrostis rossae.*)

The genus *Agrostis* is composed of about 100 species, most of which are found in the North Temperate Zone.[1] As indicated by its com-

[1] Hackel, Edward, "The True Grasses," p. 111, 1890.

F-11G

MARSH PINE GRASS (CALAMAGROSTIS CANADENSIS).

A portion of the characteristic creeping rootstocks is shown.

F-120

TUFTED HAIR-GRASS (DESCHAMPSIA CAESPITOSA).

mon name, alpine redtop is typically a plant of the high grazing lands. On the Wallowa National Forest it is not found below about 6,500 feet. It grows well up to and even a little beyond timber line, having approximately the same distribution as mountain bunchgrass, with which it is commonly associated.

This species, like a great many typical upland plants, is short, rarely exceeding 8 inches in height (Plate VIII). Unlike cultivated redtop, it is distinctly tufted instead of stoloniferous, and has a large number of narrow basal leaves from one-third to one-half the length of the culms. The panicle is rather contracted, about 2 inches long, and the spikelets are purple-green merging into red, one-flowered, with awnless glumes.

Alpine redtop seems best adapted to a well disintegrated basaltic soil relatively rich in humus, characteristic of glades and open plateaus. It wilts beyond recovery in soils of this type having a water content of from 8.5 to as low as 7 per cent. Good stands have often been seen in rather moist habitats, but, as a rule, it succeeds best and is more commonly met with in well-drained soils. Being a bunchgrass, it never completely covers the ground, but in certain localities it is sometimes the main species.

The average time during which the flower stalks were sent forth in 1907, 1908, and 1909 was four weeks. In 1907 they first showed on July 5 and continued to be sent forth until August 15. The seed crop was fairly well ripened at the end of the first week in September.

The germination power of the seed in 1907 was 29 per cent; in 1908, 38 per cent; and in 1909, 41 per cent. For an upland perennial grass these figures are considerably above the average, and in favorable situations the reproduction was good.

While not eaten with the same relish as are a number of its close relatives, alpine redtop is grazed by sheep to a considerable extent, particularly in the fore part of the season. After about August 15, when all the flower stalks have been sent up, the leaf blades become rather tough and unpalatable, and other plants are then preferred. The shortness of its leaf blades, its scattered growth, and the comparatively short period during which it is eaten with relish affect its importance as a forage plant.

Pine Grass.

(*Calamagrostis suksdorfii.*)

The genus *Calamagrostis*, to which pine grass belongs, contains about 130 species widely distributed throughout temperate and mountain regions. Thirty-eight species, mostly native, occur in North America, mainly in the West. Only three occur in the Southern States, and six of those States are without a single species.

Botanically *Calamagrostis* is closely related to *Agrostis*, the genus to which redtop belongs, but may be distinguished from it by the long, soft, fine hairs on the callus or hardened base of the floret and by the prolongation of the axis of the spikelet behind the palea.

Pine grass makes its most luxuriant growth in the Transition zone, where it grows mainly under the relatively open forest of western yellow pine (*Pinus ponderosa*). It is also found in the Canadian zone, where it often ranks first in abundance and importance among the grass species. In the Hudsonian zone it is found only in the warmer situations of the lower altitudes. (See Plate IX.)

Pine grass (Plate X) may be recognized by its perennial character and its abundant, well-developed, creeping rootstocks which produce a continuous, closely matted sod or turf. The culms, somewhat bunched, grow from 1 to 3 feet tall, and usually bear three short, smooth leaves; the rather numerous lower or basal leaves are somewhat involute, flexible, and smooth. The panicle, pale green until the plant is mature, is contracted and densely flowered, the spikelet bearing but one floret. One pronounced character by which the species may be recognized at a glance is the ring of stiff hairs at the junction of the sheath and blade.

The fibrous, widely spreading and deep root system, make it possible for pine grass to grow in exposed situations where the soil is relatively dry during most of the growing season. (Tests for drought resistance show that this species usually fails to regain its form after wilting notably in a soil containing an average water content of 8.5 per cent. In the case of two specimens turgor was regained in a soil which contained but 5.5 per cent of moisture.)

Owing to the warm and relatively dry situations generally inhabitated by pine grass, the flower stalks begin to appear about July 1. The number is comparatively small, and production continues until September 1. On the higher areas flower-stalk production is invariably sparse, with the period of production extending from July 20 to the end of the season. The seed begins to ripen on the lower ranges in late July, and the period of maturity extends until the middle of September. On the higher ranges the first seed ripens by August 10, and the maturing period lasts until unfavorable weather conditions in September. Seed of the last flower stalks produced seldom ripen.

In fertility, the seed of pine grass [1] ranks about the highest of the native species studied. The lowest vitality observed occurred in 1907, when an average of 58.2 per cent was obtained. In 1908 and 1909 averages of 76 and 74.5 per cent, respectively, were secured. Seed collected at different times in the Transition zone yielded the highest

[1] The seed used in these tests was collected in the upper Canadian zone in the latter part of August of each season.

F-13Q

SLENDER HAIR-GRASS (DESCHAMPSIA ELONGATA).

F-14Q

SPIKED TRISETUM (TRISETUM SPICATUM).

results in nearly every case, one germination test, the highest of all, giving 98.5 per cent.

Among stockmen there is much diversity of opinion as to the forage value of pine grass. While it may not be included in the category of choice forage plants, except in the spring when it is young and tender, yet it plays a valuable part on the range. In the spring of the year the leaf blades are eaten with nearly as great relish as any of the native grasses, and judging from the condition of the stock feeding upon it, the species has high nutritive qualities. From early spring to about the middle of July, on the lower ranges, all classes of stock graze it closely and with considerable relish. In the latter part of July, however, the tissues of the leaf blades become fibrous and tough, the plant is not grazed with relish, and is then considered to have a much lower nutritive value. In the fall of the year, after the rains have started, it is again grazed to a limited extent, since the leaf blades are somewhat softened by the precipitation.

Bluejoint.

(*Calamagrostis canadensis.*)

Bluejoint or marsh pine grass, because it is less abundant and less important than pine grass, is not so well known to stockmen as the latter. Though its distribution is about the same, it does not inhabit pine forests, but grows in marshes and swales and along moist stream banks. The local name is derived from its resemblance to typical pine grass, to which it is closely related.

The two species may readily be distinguished by the panicle (compare Plates X and XI), which in pine grass is dense or contracted and pale green, while in bluejoint it is very loose and open and tinged with brown or pale purple. The latter does not have the characteristic ring of stiff hairs at the junction of the sheath and blade. The culms of marsh pine grass are erect, from 1½ to 3 feet high; the leaves, smooth, long, wide, and distinctly flat. It has rather shallow, lateral roots. Reproduction by root stocks is prolific, and dense stands are common in favorable situations.

The wide, flat leaves, shallow roots, and the situations in which marsh pine grass grows indicate its inability to withstand drought. The soil in which it occurs is well supplied with moisture, but is not especially rich in organic matter. In some of the tests the plants did not succumb until the water was reduced to nearly 11 per cent. In the case of two tests the specimens recuperated from the wilted condition when the soil contained an average of 14 per cent of moisture.

The flower stalks begin to appear about June 25, and by July 20 are nearly all sent up. Mature seed can usually be found by August

1, and by August 20 the main seed crop has ripened. The seed has a high power of germination. The average for all tests made was 71.5 per cent, with a minimum germination of 59.5 per cent.

Owing to its rank growth bluejoint is better suited to cattle and horses than to sheep, yet the latter eat the leaf blades, though rarely the flower stalks even when young. Because of its restriction to moist situations, it is not very abundant, and consequently furnishes a comparatively small amount of forage.

Tufted Hair-Grass.

(*Deschampsia caespitosa.*)

Tufted hair-grass (*Deschampsia caespitosa*) is a member of the same tribe as cultivated oats. Though from its general appearance this fact would not be recognized, yet botanically they are closely related. Tufted hair-grass is often mistaken for redtop, mainly because of its loose panicle, but morphologically it is very different. Redtop has but one flower in a spikelet, while tufted hair-grass has two perfect flowers.

The genus *Deschampsia* is represented by about 20 species, adapted mainly to the cold and temperate regions. About 6 species are found in the western part of the United States.

Tufted hair-grass is a perennial tufted species with rather deep and spreading fibrous roots. The culms are from 1½ to 3 feet tall, erect, and smooth, or in some specimens slightly rough, the leaves mainly basal and very numerous, flat, and often ascending to half the length of the culms. The spikelets, bearing two perfect flowers, are small and shiny, and the panicle is open, the branches widely spreading. Both the empty and the flowering glumes are shiny in appearance (Plate XII). The latter are notched at the apex and bear a short awn on the back.

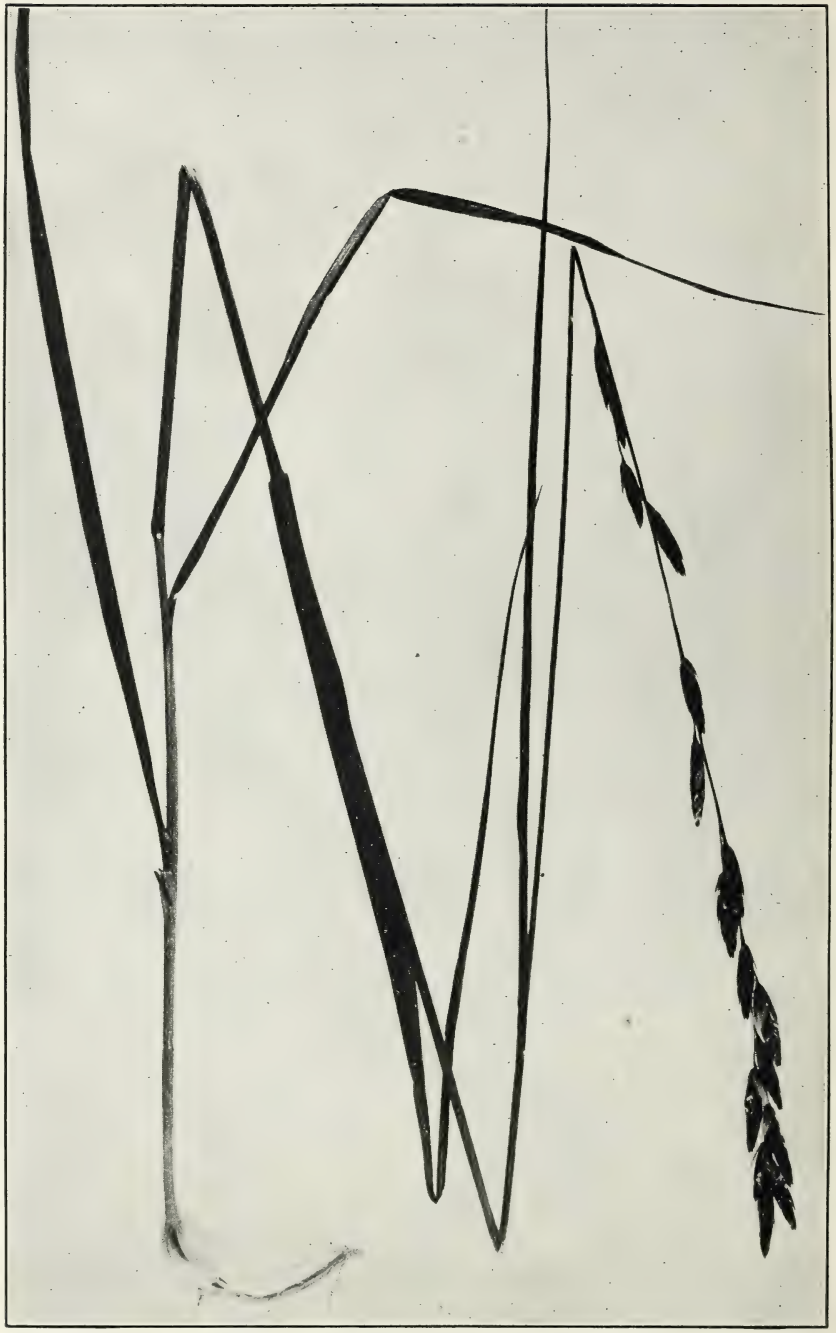
This species is rarely found in dry situations, but grows abundantly in moist meadows, canyons, and bottom lands, where it frequently predominates. Concerning its density of stand and rankness of growth F. Lamson-Scribner [1] states that is has a record of producing 10,209 pounds of green and 3,318 pounds of dry hay per acre. The minimum amount of soil water with which it will grow varies between 11.5 and 14.5 per cent. In soils containing less than this amount of moisture the wilted leaf blades failed to regain their turgidity.

The first flower stalks appear about July 20, and their production continues until about August 15. As with most species in moist soils, the flower stalks are not produced as early as in the drier situations. The time required for the development of the seeds is rather prolonged, and well-matured seeds are rarely found until

[1] Economic Grasses, U. S. Dept. of Agr., Div. Agrost. Bul. 14, p. 32, 1900.

F-15G

MOUNTAIN JUNE GRASS (KOELERIA CRISTATA).



F-16Q

ONION GRASS OR MOUNTAIN BLUEGRASS (MELICA BELLA).

September 1. By about the middle of September the crop is usually well ripened, and, for the most part, disseminated.

The germination per cent is about the average for an upland plant, the average for all tests conducted during the three years of study showing 26.4 per cent for the seed crop from the Hudsonian zone, where the revegetation studies were made. Seed collected in the Canadian zone germinated as high as 50 per cent. Some seed companies handle seed of this species grown in Europe, which as a rule has a fair germinative strength. It is sold for about $22 per 100 pounds.

This species is an important forage plant because it occurs frequently throughout the Hudsonian zone, is often met in the Canadian zone, occurs in sufficiently dense stands to make it an appreciable factor in meadow crops, and is eaten with relish. So far as texture is concerned, it is always desirable for cattle and horses, but is often too rank and coarse to be of the highest value for sheep. Nevertheless, as a rule, sheep graze it closely. Densely vegetated meadows of this species grazed by sheep comparatively early in the summer when the root leaves are tender may have the appearance of a newly-mown lawn of bluegrass, so closely is the forage removed. Up to about August 15 tufted hair-grass is highly relished, but after that date the leaf blades take on a fibrous or somewhat woody texture which greatly lessens their palatability. In the latter part of the grazing season it is not usually grazed closely unless it has been cropped earlier in the season, a condition which results in prolonging the growth of the vegetative parts. The aftermath is eagerly consumed by all classes of stock, and especially by sheep. Observations indicate that this species withstands trampling and close grazing better than any other valuable forage grass in the region studied. This fact is due both to the habit of growth of the plant and to the nature of the situations in which it grows.

Slender Hair-Grass.

(*Deschampsia elongata.*)

Slender hair-grass, though closely related botanically to tufted hair-grass, differs widely from it in general appearance (Plate XIII). Like tufted hair-grass it is a perennial and grows in tussocks, though the latter seldom attain a diameter exceeding 4 inches, and more often are only one-half that size.

Slender hair-grass bears the appearance of an annual grass in that it is very shallow rooted and sends up a preponderance of slender naked seed stalks. The latter are erect and from 8 to 16 inches tall. At the base a prodigious number of narrow, rather smooth but very short root leaves are produced. The panicle is long, often fully one-third the length of the culm, and usually not widely branched.

In the region studied this species has a wide distribution. It occurs most abundantly and grows most luxuriantly in the Canadian zone, though it is met with in a variety of situations in both the upper and lower contiguous zones. In fact, the tendency of slender hair grass to adjust itself to various sites is a marked characteristic. In the well-aerated, finely disintegrated, basaltic soil of the plateaus in the Hudsonian zone this species does not wilt notably until the water content of the soil falls to between 8.5 and 10.0 per cent—a relatively low figure. On the other hand, simultaneous drought tests conducted in soils rich in organic matter, and where the plant had had access to a high per cent of soil water at all times, resulted in destructive wilting of the plant when the soil-water content was as high as 15 per cent. In moist situations a meager root system is developed, and on dry sites, while the root rarely penetrates deeply into the soil, it spreads over considerable surface.

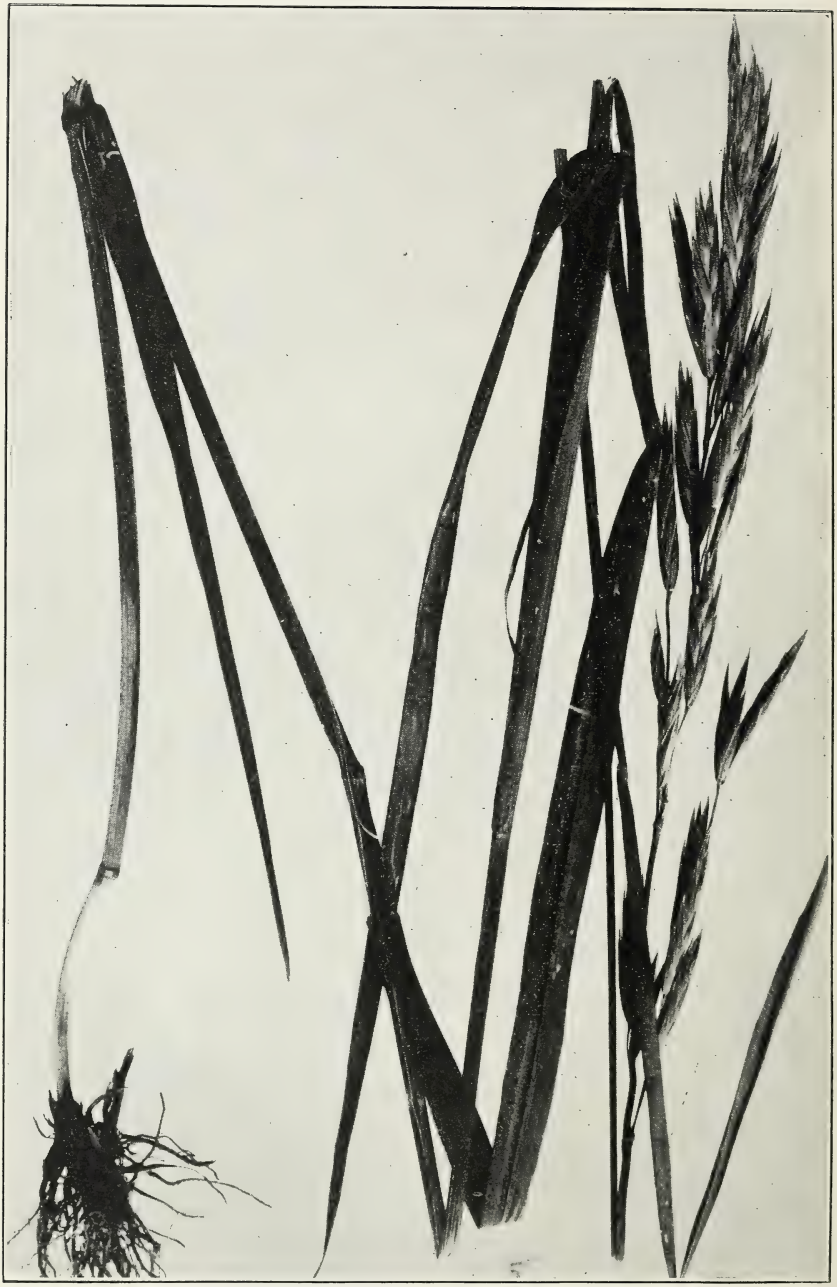
The flower stalks begin to appear about July 10 in the drier situations, and a week or so later in moist places. By August 1 the majority have put in their appearance. Mature seeds are found as early as August 5, while the bulk of the seed crop is matured by August 25. The tests made for seed vitality were confined to the year 1909, and showed an average of 41.5 per cent. On lower ranges somewhat higher figures were obtained, 56.5 being the maximum.

The grazing value of this plant is relatively low, and in this respect it does not compare favorably with tufted hair grass. Owing to its shallow roots the plant is frequently pulled up. Sheep grazing on this plant, especially early in the season when the soil contains a high per cent of moisture and the roots are readily pulled out, start masticating the leaf blades, but usually expel them when they find that roots and clinging dirt form the dessert to their diet. After a few experiences of this kind they crop it but little. Since the tussock is small, horses often pull up the entire tuft, and after eliminating the greater part of the clinging dirt by shaking it vigorously and rubbing it upon the ground, sometimes devour the plant. After about August 15 the leaves become air dried, and slender hair grass is then disregarded as a forage plant by all classes of stock.

Another species known as black hair-grass (*D. atropurpurea*) occurs in scattered stand in open situations throughout the Hudsonian zone. Being restricted to high elevations (it rarely occurs below 6,500 feet), the flower stalks are not seen until July 15 and they continue to be produced until about August 25. No seed is matured until about September 1 and very little fertile seed is developed even in most favorable seasons. Reproduction takes place vegetatively by means of offshoots arising from root stocks.

F-17Q

LITTLE BLUEGRASS (POA SANDBERGII).



F-18Q

SHORT-AWNED BROMEGRASS (BROMUS MARGINATUS).

The sheath on the basal portion of the culm was accidentally removed before the photograph was taken.

The plant, being late in maturing and the herbage green and tender throughout the season, is grazed with much relish by all classes of stock from early spring until late autumn.

It occurs in dense stands only in small isolated patches and consequently is not highly important as a range plant.

Spiked Trisetum.

(*Trisetum spicatum.*)

The genus Trisetum belongs to the oat tribe. and is represented by about 8 species in the western United States, most of which occur in the higher mountains.

The zonal distribution of *Trisetum spicatum* is typically Hudsonian, though it occurs commonly above timber line and is found to a limited extent on north and east slopes in the Canadian zone. The plant occurs irregularly in scattered stands throughout the upland ranges in exposed situations on well-drained soils. It is frequently associated with slender hair-grass, but is more deeply rooted. As its habitat indicates, spiked trisetum is not readily killed by drought. Most specimens tested were able to regain turgor and, of course, absorb water from the soil until its content was reduced to from 7.5 to 9.5 per cent. As a rule the plants died very gradually, probably owing to the highly developed contrivances for protection against rapid transpiration.

The plant is a perennial of tufted habit with deep and widely spreading fibrous roots (Plate XIV). It may usually be recognized by the soft downy pubescence on the sheaths and culms, which has given it the local name "wool grass," although this is a widely variable character, some individuals appearing nearly smooth. Most specimens appear downy silvery white. The culms vary in height from 1 to 2 feet. From the crown arise a large number of short, flat, and rather wide basal leaves. The panicle is spikelike and cylindrical in character, somewhat contracted and shiny. The lemma or flowering glume bears on the back a rather inconspicuous, slender, soft, divergent awn.

The flower stalks appear about July 10, and a month later production is usually complete. The seeds do not begin to ripen before about August 25, and generally are not all matured by the time inclement weather comes in the fall and prevents further development. As a result, viable seed are produced only on the earliest flowering stalks. In 1907 the seed crop averaged 11 per cent germination, and in 1909, 28 per cent. No tests were made in 1908.

While spiked trisetum occurs in scattered stands, it is widely distributed and furnishes more forage than is ordinarily thought. The leaf blades are eaten in preference to many other species, so that little

of the herbage goes to waste. In addition, the plant begins to grow early in the spring and does not ripen until late in the fall, so that it remains fresh and palatable throughout the season. Though it withstands trampling well, natural regeneration on protected ranges is scant as compared with that of other species whose seed crop has about the same or even lower viability.

Mountain June Grass.

(*Koeleria cristata.*)

Koeleria, though a genus of only about 15 species, has wide geographical distribution. In the United States mountain June grass is the only representative of common occurrence and much economic value.

Mountain June grass is a tufted perennial species, 1 to 2 feet in height, the culms of which are usually pubescent just below the panicle. The leaves, which are mainly basal (Plate XV), are unusually numerous. They are flat or slightly inwardly rolled, vary in texture from smooth to rough, and are often hairy. The panicle, pale green in color, is spikelike when young, but during fertilization is rather widely expanded. The lemmas or flowering glumes are glossy, and the plant can nearly always be recognized off hand by the shiny character of the panicle.

This plant often inhabits very dry situations, though on the lower ranges it matures comparatively early and so largely avoids the driest part of the season. In the higher altitudes moisture is usually present a few inches below the surface. Most of the plants tested wilted strikingly, usually beyond recovery in a soil having from 10 to 13.5 per cent water content. Thus the soil-moisture requirements in the particular soil type in which it grows are about the average.

The flower stalks on the upland ranges were put forth in 1907 between July 10 and 28; in 1908 between July 10 and 25; and in 1909 between July 5 and 25. The seeds begin to ripen about the latter part of the second week in August, but the entire crop is not matured until about September 10.

The germinative power of the seed is low. In 1907 an average of three tests gave 16 per cent and in 1908 14 per cent. No test was made in 1909. However, on the lower areas in the Transition zone, for example, the seed was somewhat more viable, though there was no marked contrast in the germinative power.

Mountain June grass is of considerable importance as a forage plant in the region studied, and few species are more eagerly eaten. The long, soft, and numerous crowded basal leaves are consumed by sheep, cattle, and horses in preference to many more abundant forage plants when green, and, like mountain bunch grass, the leaf blades but not the flower stalks are eaten by sheep after the seeds have reached ma-

F-19Q

SOFT CHEAT OR CHESS (BROMUS HORDEACEUS).

F–20Q

TALL MEADOW-GRASS (PANICULARIA NERVATA).

turity. It is found rather sparingly on the higher ranges, but is fairly abundant in glades and sparsely timbered areas of medium moisture in both the Canadian and Transition zones.

Onion Grass.

(*Melica bella.*)

The species of the genus *Melica*, over 50 of which have been described, are distributed throughout the temperate and subtropical regions. Several are of value for grazing, but the genus as a whole, contains few species of high economic importance.

Onion grass enjoys a rather wide distribution, growing luxuriantly in the upper Canadian zone, but also succeeding well in the Hudsonian zone. It rarely occurs as the predominating species in a plant formation, but appears in rather scattered stands in association with such species as mountain bunch grass and short-awned bromegrass, on well-drained soils. In its ability to exist in soils of low water content it is very similar to mountain bunchgrass, the plant wilting beyond recovery from this condition when the soil water is reduced to from 6.3 to 8.5 per cent.

Onion grass is a perennial, bulbous at the base, fibrous rooted (Plate XVI). Culms 1 to 2 feet tall, sheaths and blades smooth or slightly rough to the touch. The panicle is sparsely branched, and the spikelets usually bear 5 flowers. The lower or empty glumes are shorter than the scale of the floret, and both the glumes and the lemma, especially the part of the latter naturally exposed, are dark purple when young, fading to light brown upon the approach of maturity.

The flower stalks appeared from July 20 to August 10, in 1907, July 15 to August 15 in 1908, and July 10 to August 15 in 1909. In 1908 matured seeds were not found until August 20, and in the other two seasons the seed-maturing period was even later; in fact, this function was so much delayed in many situations, particularly where grazing had been carried on excessively, that a large amount of the seed failed to mature at all.

Germination tests showed the seed to have a low vitality. In 1907 negative results were obtained, and in 1908 only 4 per cent germination was secured. In 1909 no germination test was made. From these data and the fact that it is not regenerating on the range, the species would seem poorly adapted to the revegetation of depleted ranges.

Notwithstanding the fact that onion grass has a wide distribution and ranks high in palatability, its scattered growth restricts its value as a forage plant. It starts growth early in the spring and, since it continues activities until late in the season, is relished throughout the summer by all classes of stock, and especially by sheep.

A species of the same common name, closely resembling *Melica bella* and nearly as widely distributed and as important economically in the region studied, is *Melica spectabilis*. In habit of growth and general appearance the plants are very similar, both being bulbiferous and growing to practically the same height. In contrast with the rather dull spikelets of *M. bella*, however, those of *M. spectabilis* are bright in appearance and the glumes are membranaceous; the pedicels of the former are stiff and erect, whereas those of the latter are slender and flexuous. The period of flower-stalk production and seed maturity is virtually the same as in the case of *M. bella*, and the viability of the seed crop is also very low.

Little Bluegrass.

(*Poa sandbergii.*)

The genus *Poa* is composed of about 150 species widely distributed in temperate and cold regions. In the western United States about 75 species have been reported. The value of the bluegrasses for hay and forage is well known. Cultivated Kentucky bluegrass is closely related to little bluegrass.

Little bluegrass is distinctly a plant of the Transition zone, though through its ability to adjust itself to more or less adverse conditions it succeeds remarkably well on upland ranges and furnishes an abundance of forage. While at higher elevations it often grows luxuriantly in rich clay loam soils, usually it inhabits inferior shallow soils. On typical scablands and rocky areas it is the most common and characteristic species. Owing primarily to its ability to withstand drought and wide variation in temperature, the range of distribution of little bluegrass in the region studied is unusually broad. It grows profusely in the lower limits of the Transition zone, about 2,000 feet, and is also common on ranges of 8,000 feet elevation. On such situations it is almost invariably confined to scablands and poorly disintegrated soils on the warmer south and west exposures. In the tests made to determine its drought resistance, little bluegrass did not show signs of complete wilting until the soil water was reduced to between 6.5 and 7.8 per cent.

Little bluegrass is a perennial (Plate XVII) and grows in tussocks not usually exceeding 8 inches in diameter. It has coarse, deeply penetrating roots, which withstand trampling remarkably well; smooth culms, slightly decumbent at the base, 1½ to 2 feet in height; close erect panicles composed of spikelets of 3 to 5 florets; and a superabundance of narrow, short, and rather flat, or sometimes slightly folded, blue-green basal leaves.

The flower stalks of little blue grass are among the earliest to appear on the range. This is due, first, to the character of the situations in

F-21Q

BIG BUNCH GRASS (AGROPYRON SPICATUM).

F-22Q

MOUNTAIN WHEAT GRASS (AGROPYRON VIOLACEUM).

which the species grows on the higher ranges, and second, to the inherent tendency of the species to complete its development at a very early date in its lower zone. The flower stalks on the upland ranges appeared from July 10 to August 1, July 10 to August 10, and July 5 to August 5, in 1907, 1908, and 1909, respectively. The seeds began to ripen in the latter part of July, and, except in 1907, the seed crop had matured by August 20.

The seed crop developed in the high mountains has a low vitality, the average for all tests made for the Hudsonian zone for the three years being only 7 per cent. In contrast to this, seed grown in the Transition zone showed average germination of 38.4 per cent.

As a forage for sheep, horses, and cattle early in the season, little bluegrass can hardly be surpassed. The entire plant is readily consumed until the seeds begin to reach full development. After the seeds have matured, however, which they do early in the summer, the plant is neglected for the more palatable tender species. In the fall of the year, when the bulk of the range plants are air-cured, little bluegrass again becomes one of the choice species.

Other bluegrasses occur in the mountains, but as a rule are so scattered as not to merit special mention. The species most commonly met with, in order of their abundance, are *P. brachyglossa*, *P. paddensis*, and *P. ampla*.

Short-awned Bromegrass.

(*Bromus marginatus.*)

The genus *Bromus* is closely related botanically to *Festuca*, to which mountain bunchgrass belongs. In general, it differs in having larger spikelets and a toothed apex on the lemma, or flowering glume.

Short-awned bromegrass (Plate XVIII) is a perennial species, and on favorable situations almost invariably forms a dense turf. The culms are erect and stout, from 3 to 4 feet in height, the sheaths are usually clothed with scattered, rather long, soft hairs; the panicle is erect and somewhat narrow, of a purple cast, and from 4 to 8 inches long, with seven to nine flowered spikelets, the florets coarsely pubescent, with two rather pointed hyaline teeth at the apex and the midrib extending into an awn one-fourth inch long.

Short-awned bromegrass has rather a wide distribution in the region studied, but grows most luxuriantly between 4,000 and 7,500 feet elevation, where it generally inhabits the better soils of medium moisture content.

It grows in dry situations on open plateaus, in friable loam soils, and in canyons, and often predominates on the banks of streams. The plant did not wilt destructively until the moisture in the soil was reduced to between 5.5 and 8 per cent.

The flower stalks begin to show about July 25, and by August 10 are usually all produced. Matured seeds have been observed as early as August 10, and are usually pretty well ripened by September 1. Dissemination takes place almost immediately upon maturity.

Seeds of this species are above the average in germinating power. Seed vitality for the three years beginning with 1907 was 38, 47, and 58 per cent, respectively. On the lower ranges a germination as high as 85 per cent was obtained.

The forage value of short-awned bromegrass is relatively high. Because of its rank growth and the coarseness of the culms, however, it is more valuable for cattle and horses than for sheep, although if grazed when young the latter class of stock often entirely consume it. At a later period of growth the culms develop an abundance of crude fiber, and sheep then consume only the leaf blades and the panicle with its spikelets of developing grain. Horses are particularly fond of the grain both in the matured state and when green, and stockmen consider it equal to oats in nutritiousness. When this species is grazed off early in the summer it continues to grow luxuriantly, and at the close of the season has produced a second crop of leafy foliage equal in palatability to the early crop. Under such treatment, however, no seed stalks are produced.

On the Wallowa National Forest a variety of short-awned bromegrass, *B. marginatus seminudus*, and three other species, namely, rattlesnake grass (*B. brizaeformis*), *B. richardsonii*, and soft cheat (*B. hordeaceus*) have been collected. Because of the sparseness of all these forms except the last, this will be the only one discussed.

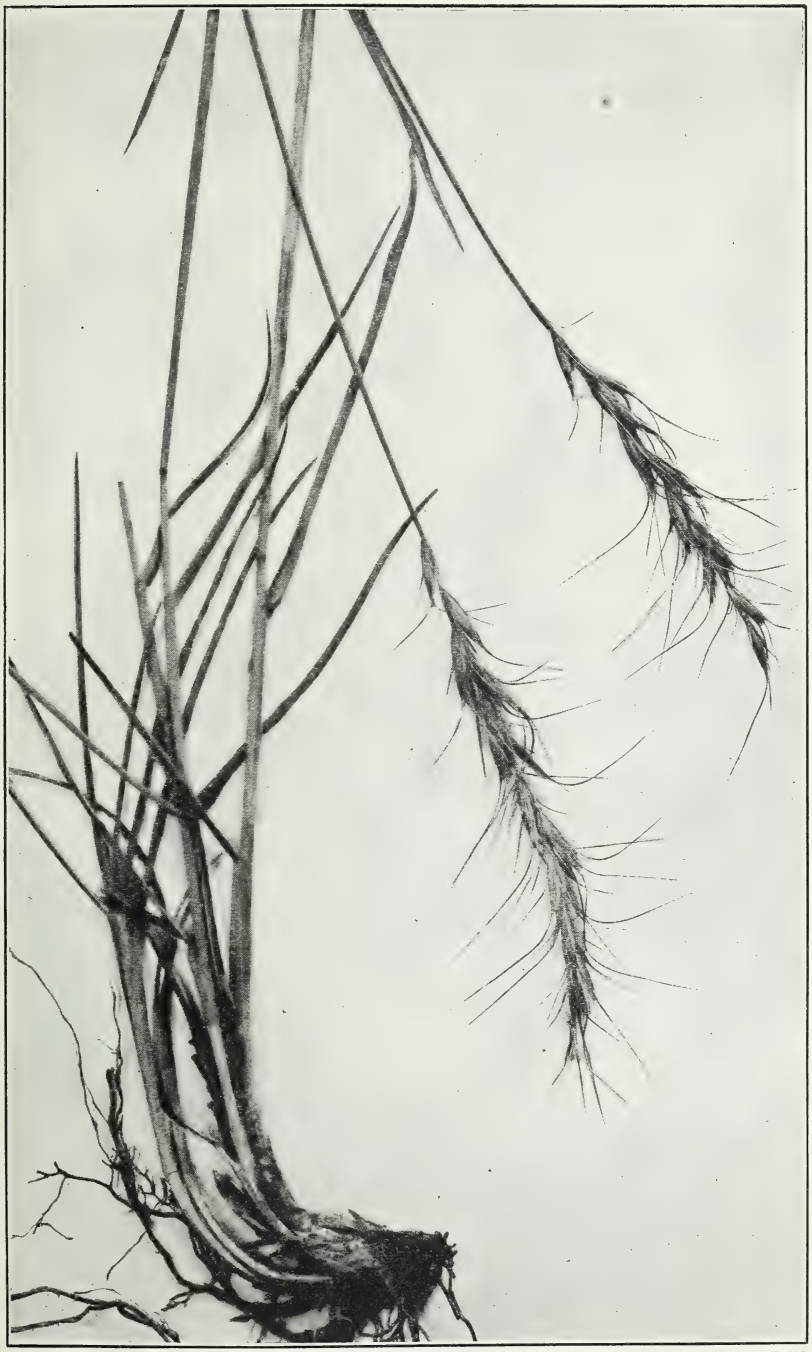
Soft Cheat.

(*Bromus hordeaceus.*)

Soft cheat or chess, an annual native to southern Europe, has taken possession of deteriorated grazing lands in Washington, Oregon, and certain localities in California. On the lower ranges of the Wallowa National Forest, where germination occurs in the fall, it produces a first-class early spring feed when little else is available.

Soft cheat (Plate XIX) has an erect growth. The culms, which are often very hairy at the nodes, attain a height of from 1 to 2 feet and are subtended by sheaths bearing long flexible hairs often of a silvery-white luster. The leaves are long and narrow, somewhat pubescent or smooth, and rather numerous for an annual species; the panicle is narrow, contracted, and erect, the spikelets from 5 to 13 flowered. Extending from the lemma or flowering glume is a stout, straight, or when old, slightly twisted awn, about $\frac{1}{3}$ inch long, somewhat flattened near the base.

Soft cheat is well adapted to the Transition zone, but grows luxuriantly in the Canadian zone, and is occasionally met with in



F–23Q

RED BUNCH GRASS (AGROPYRON FLEXUOSUM).

F-24Q

SMOOTH WILD RYE (ELYMUS GLAUCUS).

the Hudsonian zone, though there it is of little forage value. It makes its best growth on shallow clay loam soils, where, notwithstanding its shallow roots, it remains green throughout the summer. External hairy contrivances protect the plant from transpiration.

Wilting beyond recovery does not take place until the soil moisture falls to or slightly below 5.5 per cent, a condition which very few herbaceous species can withstand. Owing to its ability to succeed in dry soils and to withstand long periods of drought, and because of its good seed habits and aggressiveness, soft cheat is valuable as a binder for exposed soils.

On the higher ranges in the Canadian zone, and in those parts of the Hudsonian where it occurs, the flower stalks are mostly produced by July 15. The seeds are usually matured by August 10. In the Transition zone the seeds are ripened a month earlier. Seed collections made on the upland ranges at an altitude of 6,000 feet yielded an average germination of 48.2 per cent, while seed grown in the Transition zone during the same seasons averaged 78.5 per cent. This wide difference is doubtless due to the more favorable temperature in the lower zone.

Since the forage of soft cheat is produced exceptionally early, it is of special value at that season, and the leaf blades are then eagerly eaten. There is diversity of opinion among stockmen as to the nutritive qualities of this grass. Many claim that it is a valuable feed when supplemented with other species of grasses and weeds, but owing to its "washy," succulent nature in the spring of the year, it is not conducive to putting on solid fat. Miners say that their pack animals fatten quickly upon it when left at leisure, but when grazing upon it exclusively they are unable to work without excessive loss of flesh. After the seeds have ripened the plant is of very little forage value.

Tall Meadow-Grass.

(*Panicularia nervata.*)

The genus *Panicularia* belongs to the same tribe as Kentucky bluegrass and mountain bunch grass. It contains about 20 species, most of which are found in North America. As its common name implies, tall meadow-grass usually attains a good height. The leaf blades are flat, smooth beneath, and rough above, and the sheaths are rather rough throughout. At maturity the somewhat purplish panicles with long flexible branches are usually drooping.

This species is closely confined to moist situations, and is able to thrive in rather deep shade. It is almost invariably associated with slender reed-grass and various species of sedges and rushes of high water requirements. It occurs rather extensively in moist situations in the Canadian zone, and is often the chief species in favorable spots in both the Hudsonian and Transition zones.

Since tall meadow-grass is entirely restricted to wet soils, the root system is not extensively developed, and it requires a relatively high amount of moisture to supply its needs. In its typical habitat it wilted beyond recovery when the soil water was reduced to from 12 to 14.5 per cent.

The average period of flower-stalk production extends over about three weeks, beginning about July 10, while by August 1 most of the stalks have been sent forth. The seed begins to ripen about August 20, and by September 10 the crop is practically all matured and disseminated. Seeds are dropped immediately upon ripening.

The germinative power of the seed crop, as tested in 1908, gave an average of 85 per cent, and since reproduction of this species seems to be generally good, it is probable that the seed has a high average vitality.

Tall meadow-grass (Plate XX), like a number of other species with a high-water requirement, supplies only a limited amount of forage. It is relished by all classes of stock, and is probably most valuable as forage during August, since it is then less succulent than earlier in the season. Up to August 1 the flower stalks are eaten nearly to the same extent as the leaf buds, but after that period they become somewhat tough and are not usually eaten by sheep. Horses and cattle, however, continue to consume the entire plant until much later in the season.

Another species, *P. pauciflora*, very commonly associated with tall meadow-grass, has similar distribution and habits. *P. pauciflora*, however, does not occur as abundantly and, consequently, is not as valuable as a forage plant. It is readily distinguished by having 5 nerves on the lemma instead of 7, as in the case of tall meadow grass.

Big Bunch Grass.

(*Agropyron spicatum.*)

The grass tribe, *Hordeae*, to which this and the following five species belong, is of high importance in the West. The genus *Agropyron* contains about 40 species, more than half of which are found in the United States. Of these, many are highly valuable for hay and forage.

Big bunch grass or blue bunch grass, as it is sometimes called because of the characteristic blue-colored culms or stems, is a perennial with deep fibrous roots. The culms, smooth and covered with "bloom," attain a height of about 12 to 18 inches in dry situations where this grass characteristically occurs, while in deep rich soils of abundant moisture a height growth of about 30 inches is sometimes made. The leaf blades, about half the length of the culm, are mainly basal and produced in abundance. They are flat when green, but slightly rolled inwardly when the plant is air dry or suffering for lack

F–25Q

WHITE FOXTAIL (SITANION VELUTINUM).

F–26G

TALL SWAMP SEDGE (CAREX EXSICCATA).

of water. The spikes are somewhat compressed, slender, 2 to 4 inches long. The spikelets are flattened, and as shown in Plate XXI, are long, narrow, erect or spreading, 3 to 6 flowered, 4 to 12 in number. The glumes (empty lowermost two scales) are sharp-pointed but awnless; lemmas (upper flowering scales) are usually provided with stout, somewhat twisted awns ½ to 1 inch long.

The distribution and abundance of this grass are unusual. It constitutes the controlling type of plant growth below the yellow-pine zone, where it is depended upon to furnish the major portion of the fall, winter, and spring forage. In a few localities in Montana and Wyoming it grows so dense that it is of value for hay. It extends even into the Hudsonian zone (usually in scattered stand, though in favorable situations nearly covering the ground with a rank growth), and even in this grazing type produces considerable herbage. This wide distribution is due to its remarkable capacity to endure drought. It is able to exist though for several days in a wilted condition, in the basaltic-soil type of the higher ranges when there is but 5.5 to 7.5 per cent water. This accounts for the prevalence of big bunch grass on scablands, benchlands, and gritty, poorly disintegrated soils of low water content.

Flower stalks first show about August 1, appearing very irregularly until perhaps September 1. Both the beginning and completion of production are thus unusually late, and the delay in the appearance of the flower stalks is reflected both in the time of seed maturity and in the fertility of the seed. Fully ripened seeds are rarely found before August 20. The seed crop continues to ripen irregularly as long as the weather permits, but the bulk of the seeds do not reach maturity. The seed that does mature germinates rather poorly. The average for 1907, 1908, and 1909 was 16, 30, and 26.5, respectively. On the lower ranges, however, seed is matured early and evenly, and a germination of 80+ per cent is often obtained.

The large amount of herbage afforded by big bunch grass on the lower ranges, and even in the upland grazing areas, places it well toward the top of the list of important forage plants. No other grass or forage plant is so abundant on the lower areas, nor supplies so much feed. As a fall, spring, and winter feed it is preeminent. When the fall rains come on, usually in September, big bunch grass is awakened to growth, and for two months or more, depending upon the altitude and physiography, continues its activities. This tender and succulent herbage is ravenously consumed by all classes of stock in the fall as well as during the winter and spring. About the middle of June on the lower areas, however, the foliage becomes somewhat tough and unpalatable and ceases to be of high value for forage. On the higher ranges, owing to the delay in the growing period and the absence of growth in the fall, the plant is grazed

throughout the season, though it does not seem to be consumed with the same eagerness as many other species.

Mountain Wheat Grass.

(*Agropyron violaceum.*)

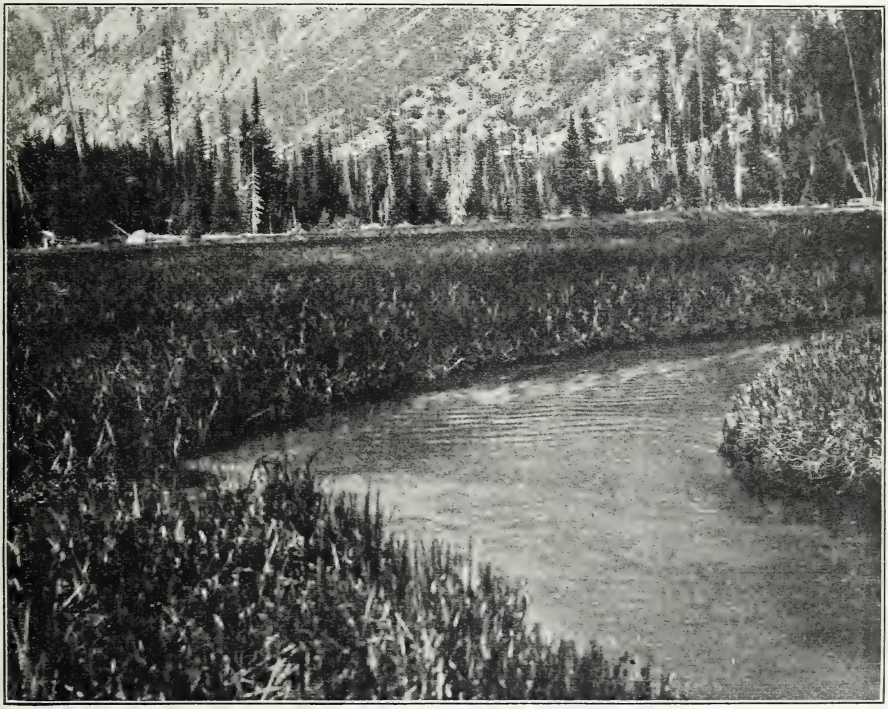
Mountain wheat grass resembles in general appearance cultivated wheat, though the two are not closely related botanically. Like big bunch grass, this species is a densely tufted perennial with deep and spreading roots. It is readily distinguishable from the former species, however, by its awnless spikelets or the presence of a slight rudimentary awn on the lemma. The leaves are unusually numerous, basal, flat, and somewhat rough, about half the length of the culms, the latter attaining a height of from 1 to 2 feet. The spikes are slender and short, the lower (empty) glumes being conspicuously three-nerved (Pl. XXII).

Though common in both the Canadian and Arctic-alpine zones, this species reaches its best development in the Hudsonian zone. As would be expected from the extensive development of the root system, it is best adapted to soils of medium moisture content. It inhabits open exposed situations, and is usually associated with big bunch grass, mountain bunch grass, and little bluegrass. In ecological requirements it resembles these species closely. In the drought tests it did not wilt beyond recovery until the soil water dropped to between 6 and 7.5 per cent.

The flower stalks begin to show during the last week of July or first days of August, and production is for the most part complete within 3 weeks after their first appearance. As a rule the seeds are ripened from about August 20 to September 1. Dissemination takes place almost immediately after maturity.

As a rule, the vitality of the seed of most of the species growing in the Hudsonian and Arctic-alpine zones reaching maturity on or before September 1 is high, and in this respect mountain wheat grass is no exception. In 1907, a very poor seed year for mountain wheat grass, there was an average germination of 78 and in 1908 and 1909, respectively, an average of 96 and 82.5 per cent. From these figures it would be expected that this species is regenerating in favorable localities. Observations show that this is true where the seed crop is worked into the soil through grazing or otherwise, but where the surface layer is undisturbed the seeds, which are large and have no awns on the flowering scales to bore them into the ground, do not germinate.

Mountain wheat grass is greatly relished by all classes of stock. Growth starts promptly in the spring, and the plant remains green and palatable until late in the fall. It is eaten with the greatest relish



F-27G

TALL SWAMP SEDGE IN A SATURATED SOIL ON MINAM MEADOWS, WHERE IT FINDS AN IDEAL HABITAT.

F-28Q

SHEEP SEDGE (CAREX ILLOTA).

up to about August 15, but considerably later in the season, even in September, the basal leaf blades, though not the flower stalks, are eaten close to the ground by sheep and cattle. Mountain wheat grass is cropped in preference to a large number of species. It is preferred in the latter part of the season, if not earlier in the year, to big bunch grass, though its scattered growth and narrow zonal distribution make it less important than the latter.

A species closely allied botanically to mountain wheat grass is red bunch grass (*A. flexuosum*), so named on account of its reddish-purple panicles and bunched habit of growth (Pl. XXIII). Its prominent awns and loose spikes, however, give a very different appearance from the former. It is sometimes mistaken for smooth wild rye (Pl. XXIV), though very different in structure. In its range of distribution, ecological requirements, period of flower stalk production and seed maturity, and in its forage value, red bunch grass is very similar to mountain wheat grass, though in most situations it does not remain palatable as late in the season.

Smooth Wild Rye.

(*Elymus glaucus.*)

The species belonging to this genus are generally known as rye grasses because of their resemblance to the ordinary cultivated rye. There are about 25 species of *Elymus*, distributed mainly throughout the north temperate regions.

Smooth wild rye is a perennial bunch grass with a strong root system capable of withstanding more than the average trampling by stock. It grows from 1 to 3 feet in height, the sheaths enveloping the culms usually being smooth, the leaves abundant, smooth beneath, sometimes rough above. The spike, 2 to 5 inches long, is narrow and slender, bearing numerous spikelets of three to six flowers. The glumes (lowermost empty two scales) are narrow, sharp pointed and rigid. The lemmas (upper flowering scales) smooth or slightly rough, each bearing a straight rough awn one-fourth to one-half inch in length.

This grass is distributed over a wide altitudinal range. It is most abundant in the upper Canadian zone, is fairly common in the lower Hudsonian zone, and is found to a limited extent in the Arctic-alpine zone. As a rule, its growth is not dense, but affords an abundance of forage because of its wide distribution. In most cases it is merged with mountain bunch grass, short-awned bromegrass, and other species characteristically associated with the latter in glades and parks. Smooth wild rye seems to be somewhat better able to succeed in moister habitats than many of the plants associated with it in exposed situations, and yet it withstands drought remarkably well. In the drought tests it did not wilt beyond recovery in some

instances until the soil moisture was reduced to 7.5 per cent, though two species died when there was a water content of 9.8 per cent.

Flower stalks begin to appear during the first week in July and continue until about the first week in August. The seed crop begins to ripen as early as August 1 and continues throughout the month, few immature seeds being found in September. The vitality of the seed crop is about the average for upland grazing plants. The average germination for the three years of study was 21.2 per cent. From this it would seem that many other species, such as mountain wheat grass, which shows an average germination of 64 per cent, would reproduce much more abundantly. Smooth wild rye, however, is one of the most aggressive species on the high grazing lands. The seedlings develop deep root systems, and a large percentage of the young plants succeed in rather adverse situations.

The grazing value of smooth wild rye is high. By many stockmen the plant is considered rather too coarse for sheep, though it is probable that its forage value in this respect is underestimated, since observations show that sheep readily graze it. Sheep rarely crop the flower stalks, because these are produced exceptionally early, and their rapid height growth soon puts the best part of them out of reach of the animals, and because the stalks are somewhat coarser than sheep relish and become unpalatable early in the season. All things considered, however, this plant furnishes good forage by the time the upper ranges are grazed, and the herbage is consumed ravenously throughout the season. Horses are fond of the flower stalks, and until the seeds are matured and disseminated the spikes or flower heads also furnish choice feed. Cattle graze the forage closely even after the seed has been disseminated.

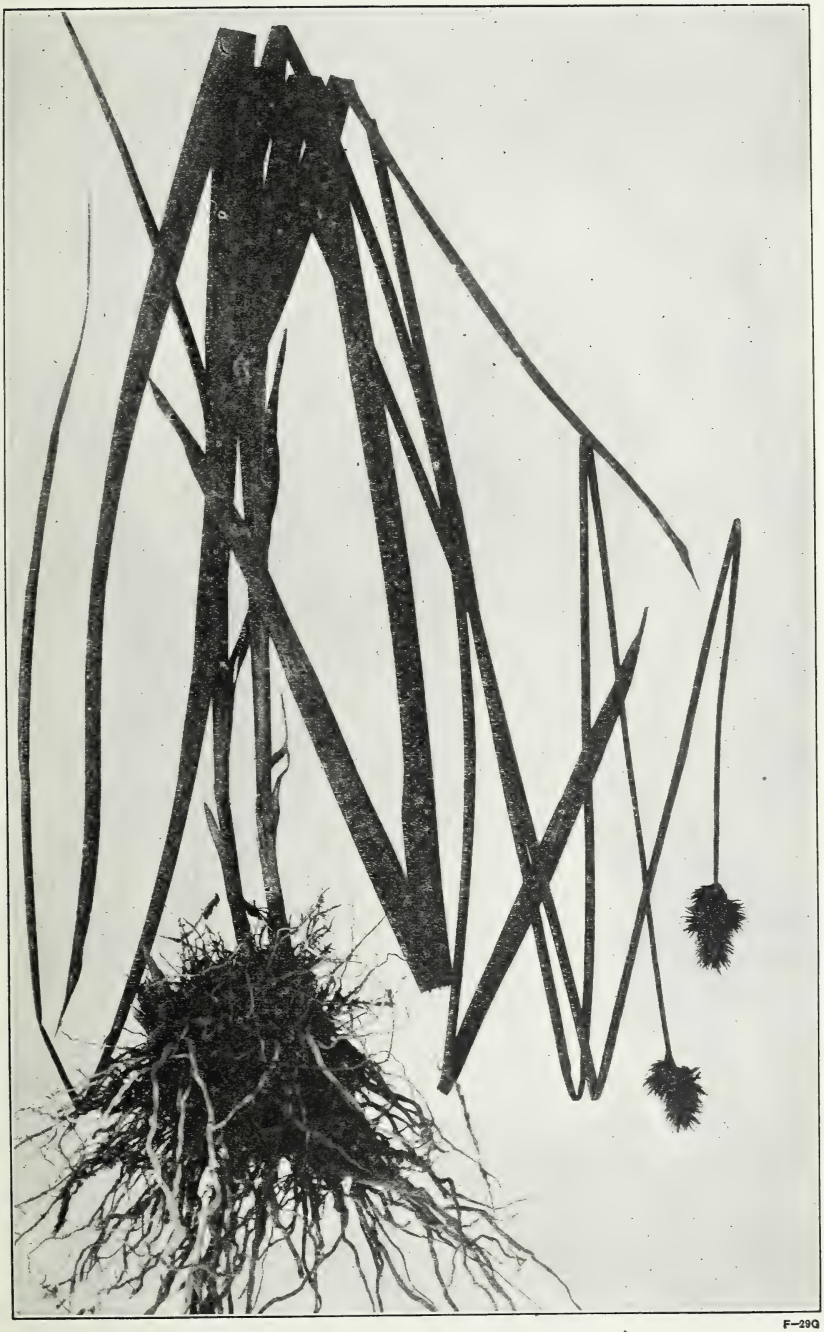
White Foxtail.

(*Sitanion velutinum.*)

White foxtail, often called wild barley, to which it is closely related, is undesirable on the range because of its low forage value and its aggressiveness on overgrazed areas.

The plant derives its name from the prominent awns, which, with the entire spike, turn a light-straw color upon reaching maturity. It is a tufted perennial grass from 1 to 2 feet tall, the culms rather conspicuously spreading on the ground, the leaf blades mainly basal, somewhat involute and rough, the upper surface pubescent. The glumes are provided with long stiff awns, which, at maturity, are strikingly divergent (Plate XXV).

White foxtail is most abundant in the Hudsonian zone. It is also found on the lower grazing types, though not to the same extent as on upland ranges. The situations most favorable to it are open glades of rather poorly disintegrated soils with moisture content



F–29Q

MARSH OR WATER SEDGE (CAREX FESTIVA).

F–30Q

MARSH SEDGE (CAREX VULGARIS BRACTEOSA).

below the average. In the drought tests the individual plants wilted excessively in soil varying in moisture from 6 to 8.5 per cent.

The flower stalks of white foxtail are among the earliest to appear, and are practically all produced by August 1. Matured seeds are found as early as August 15, and are practically all ripened by the end of the first week in September. Unlike most species, the seeds are not disseminated immediately upon reaching maturity, but persist for some time unless they are brushed off by direct contact or shaken off by some vigorous mechanical means. Wind is ineffective in bringing about a wide distribution of the seed, but stock, especially sheep, when they come in contact with matured plants, distribute the seed crop broadcast, the awns attaching themselves to the wool.

Germination tests as well as observations on the reproduction of this plant on the range indicate a high viability. In 1907 and the two succeeding seasons an average of 43, 77, and 82.5 per cent of the seed germinated under controlled conditions. The best reproduction is taking place on sparsely vegetated soils where the seed are worked well beneath the surface and where competition with other species is not severe.

The forage value of white foxtail is always low. In the spring, shortly after growth has started, the leaf blades are eaten by stock of all kinds, but this period is so short as to be negligible. Even before the majority of the flower stalks are produced the herbage becomes tough and harsh, and stockmen claim that the mouths of sheep become sore and tender if they graze it to any extent. As soon as the seeds begin to ripen white foxtail is almost wholly disregarded. If stock should consume any quantity, however, the awns may cause sore mouths and big throats, and the barbs even get into the eyes. Thus the plant is practically worthless, and the range would be better off by its absence.

GRASSLIKE PLANTS.

Distinctions Between Grasslike Plants and Grasses.

Stockmen, as a rule, do not distinguish between true grasses and grasslike plants such as sedges and rushes. The latter, because of their frequent occurrence in marshes, swales, along creek banks, and in other moist situations, are commonly referred to as "water grass," "wire grass," "swamp grass," etc., but the three distinct groups of grasses, sedges, and rushes are almost invariably spoken of collectively as "grasses."

Sedges, *Carex*, may readily be distinguished from grasses in the following simple ways:

1. The stems of sedges are triangular, jointless and solid, the leaves 3-ranked, and the leaf sheaths closed.

2. The stems of grasses are generally hollow, cylindrical, and jointed, the leaves 2-ranked, and the leaf sheaths usually split.

Rushes (*Juncus* and *Juncoides*) are readily distinguished from grasses and sedges by:

1. The flowers of rushes are regular and, though diminutive, similar in form to those of a lily, having a perianth composed of six bractlike scales, and with three to many small seeds borne in a capsule or small pod.

2. The flowers of grasses and sedges are not symmetrical, the perianth being irregular and inconspicuous or obsolete, and are subtended by husklike scales, each flower producing but a single seed.

Sedges and Rushes.

It is the general opinion among ranchers that, as compared with grasses, sedges and rushes are of low nutritive value. This idea is generally true, but when a grass species occupying a typical marshy bog is compared with sedges and rushes from a similar situation chemical analysis has shown that the food value differs but little. Practically all species of moist habitats are somewhat too succulent or "washy," notably in the spring of the year, and while they are eaten with relish at that time they are doubtless more nutritious later in the season.

A thousand or more species of sedges (*Carex*) have been described. They are widely distributed and are most abundant in temperate regions. In the United States approximately 500 species are found, about half of which occur in the Western States. The rush genus (*Juncus*) contains over 200 species.

Tall Swamp Sedge.

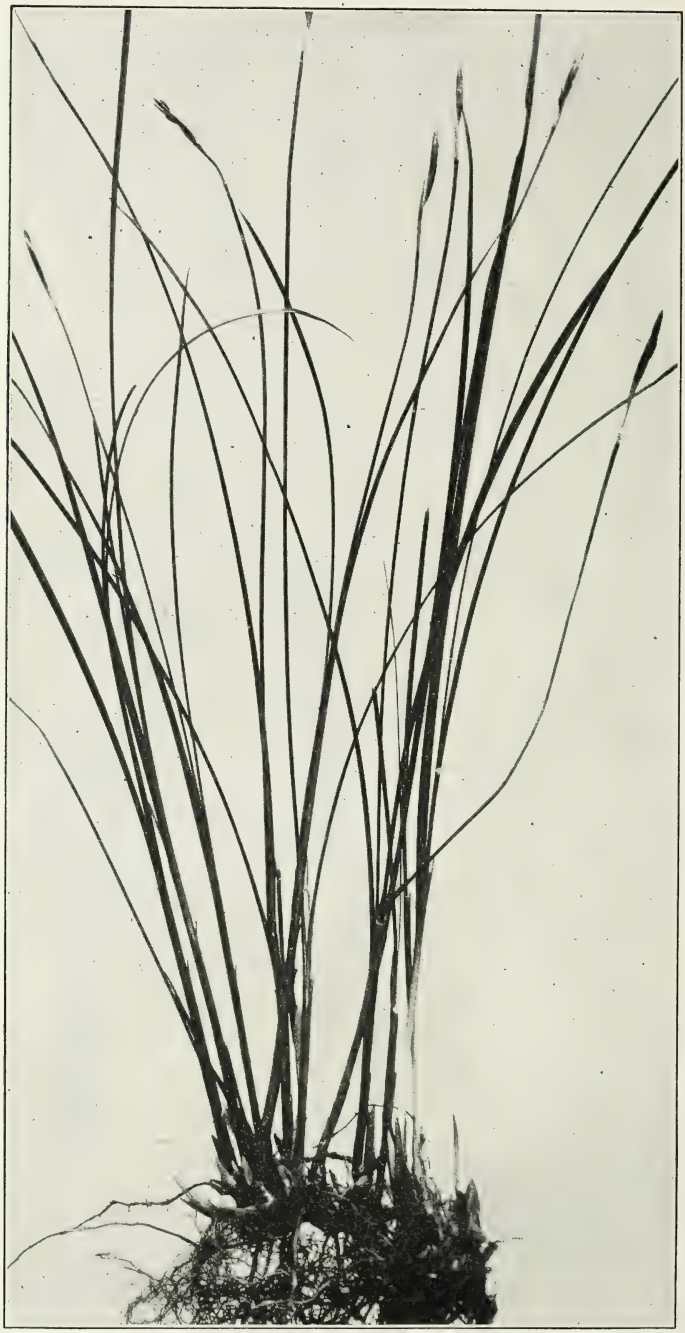
(*Carex exsiccata.*)

Because of its abundance, density of stand, and height growth, this species is one of the best-known sedges on the Wallowa National Forest. It ranges from 1½ to 3 feet in height, has coarse leafy culms, and broad, thick, flat leaves of a light-green color. The spikes, developed sometimes as much as 4 inches below the staminate flower clusters, are very short-stalked (Plate XXVI). The root system is somewhat meager, and new growth takes place abundantly through stolons and rootstocks.

The drought tests showed that this plant wilted destructively when the rich organic soil in which it grows contained, in the one case, 22.5 per cent of moisture and in the other 24 per cent. Obviously, therefore, the species is distinctly of the marsh type. In most perennial bogs, preferably in saturated soils, it grows pure, to the exclusion of other species (Plate XXVII).

F-31Q

MARSH SEDGE (CAREX TOLMIEI SUBSESSILIS).



F–32Q

ELK GRASS (CAREX GEYERI).

In somewhat drier situations, such as over-irrigated meadows, it often produces a conspicuous growth, and when associated with some cultivated grass such as redtop, is cut for hay. Tall swamp sedge is most common in the Canadian zone, but also occurs along the border of the Hudsonian zone.

The flower stocks begin to push forth about June 20, and are all out by the last week in July. The seed are comparatively slow to mature, practically none being found until the last week in August, while the entire crop is not ripened until September 15. In viability the seed ranks low. The average germination obtained from the tests made in 1908 and 1909 (no tests made in 1907) was 15.2 per cent. Low vitality in the seed of this plant, however, is of little significance, since the species propagates profusely by rootstocks.

Compared with many other species of its class, the forage value of tall swamp sedge is high, and early in the season the herbage is eaten with relish by sheep. Owing to the sheep's dislike for bogs, however, many areas densely covered with this species are not visited until the soil becomes fairly dry. In the latter part of the summer the leaf blades become tough and harsh, and sheep do not consume them with the same eagerness as in the forepart of the season. Horses are particularly fond of this plant. They graze it throughout the season and seem to do well upon it for short periods, but, if left free, withdraw to better-drained soils which afford a wholly different type of herbage. Miners and campers state that their pack animals eat tall swamp sedge readily, but are unable to do the usual amount of work when grazed exclusively upon it. It is probable, therefore, that its nutritive value is low.

Sheep Sedge.

(*Carex illota.*)

Of the bog forage plants of the genus *Carex*, sheep sedge is possibly the most important. It is a stoloniferous perennial or densely matted species about 1 foot tall, with culms usually exceeding by one-third the numerous grasslike leaves. The latter are narrow and smooth, and soft even when the plant is mature. Inconspicuous small spikes crowded into small dark brown heads distinguish it from certain other associated species (Plate XXVIII).

Sheep sedge is confined to mountain meadows, and rather closely to moist situations, though it persists in some which become comparatively dry later in the season. Conditions in the Hudsonian zone are well adapted to its highest development. The leaf blades wilted but recovered their form in the rich loam soil containing 14 per cent of moisture.

The flower stalks begin to appear about the middle of July and are practically all sent forth during the following three weeks. Matured

seeds are found about August 20, and by the end of the first week in September the whole seed crop has ripened. Data on the vitality of the seeds were obtained only in 1909, when an average from three tests gave 27.5 per cent germination.

As its common name implies, sheep sedge is a highly relished sheep forage. The leaves are tender and juicy throughout the summer, and the plant seems to be consumed with about the same eagerness at all times during the growing season. Horses, too, graze this sedge with unusual eagerness, consuming flower stalks with the same avidity as the leaf blades. Since sheep sedge is restricted to moist habitats it is, of course, not very abundant, but in favorable situations it holds its own remarkably well, and it is not uncommon to find it predominating over other sedges and more fastidious species almost to their entire exclusion.

Three other species, usually called marsh or water sedges, *C. festiva*, *C. vulgaris bracteosa*, and *C. tolmiei subsessilis*, are, on account of their general appearance, forage value, and distribution, often confused with sheep sedge. Of these, *Carex festiva* resembles it most, but differs in many minute characters (compare Plates XXVIII and XXIX). The leaves of *Carex festiva* are much broader and coarser, and are rough on the edge, and the color of the plant is light green. The other two species, *C. tolmiei subsessilis* and *C. vulgaris bracteosa* (Plates XXX and XXXI) have much more elongated spikes, of a brown-black color, which alone should eliminate confusion. The latter attains about twice the height of the former, and its culms are more acutely angular. The forage value of all three species is practically the same, though *C. vulgaris bracteosa* is relatively less abundant than the other two. *C. tolmiei subsessilis* remains palatable to stock for a longer period than either of the others, but is more abundant in the alpine or upper subalpine regions, and therefore matures later, being of little importance as forage when the other species are of highest value.

Elk Grass.

(*Carex geyeri.*)

Of the dry-land sedges, elk grass is by far the most abundant. It occurs in the Canadian and Hudsonian zones, often as the predominating species on exposed hillsides, and is among the earliest of the herbs to send forth its leaf blades. Many hillsides have been almost wholly vegetated by this species.

Since elk grass produces new plants by stolons the growth is dense and segments of a tuft are almost inseparable (Plate XXXII). The slender, angled, rough culms, about 1 foot high, exceed but slightly the harsh and rough-edged leaf blades. The spikes are slender, borne at the summit of the culm, the staminate flowers usually appearing above, and the pistillate (1 or 2 in number) below.

F-33G

RUSH (JUNCUS PARRYI).

F-340

WOOD RUSH (JUNCOIDES PARVIFLORUM).

The very nature of the habitat in which elk grass succeeds indicates its unusual ability to withstand low moisture conditions. The soil in which it grows is a coarse gravelly one, which liberates the water more readily than finer soils. Drought tests resulted in the extensive wilting of all leaf blades of the plant only when the water content was reduced to 6.5 per cent, and in some instances slightly lower. This places elk grass very near the head of the list in its ability to exist under adverse moisture conditions. Flower stalks begin appear during the last week in June, and by July 20 practically all are out. About the time that the last flower stalks are sent up matured seeds are found. By August 15 the seed crop is almost entirely ripened and disseminated. The seed has about average viability, the tests in 1907 and in the two subsequent seasons showing germinations of 6, 26, and 32 per cent, respectively.

In the forepart of the season elk grass is grazed with a certain amount of avidity, though practically every other grass species is preferred to it. It is only eaten by sheep up to about August 1, unless the stock are starved. After that date the leaves become so tough, hard, and fibrous that even horses will not graze it if other forage is available. Sheep always scatter widely when feeding upon it, doubtless searching for more palatable food.

Rush.

(*Juncus parryi.*)

Among the several species of rushes found on the highland ranges *Juncus parryi* is commonly met with, and in value is typical of other species which are abundant in the region studied.

Like most rushes of the drier situations, *Juncus parryi* is tufted, and has woody, fibrous, deep-spreading roots capable of withstanding an unusual amount of abusive grazing. The stems are thin and wiry, from 4 to 10 inches long, and the cylindrical leaves are about half the length of the flower stems (Plate XXXIII); the inflorescence, usually 2 or 3 flowered, is surpassed by a bract similar to the leaves.

Juncus parryi is confined to the high ranges. In the Hudsonian zone it occurs extensively in open, exposed situations on well-drained, often poorly disintegrated soils. It is usually associated with elk grass (*Carex geyeri*) and is just about as drought resistant, the specimens studied not wilting beyond recovery until the soil-moisture content was reduced to from 5.5 to 7 per cent. Above timber line it is found in considerable abundance in association with typical alpine species.

On the lowest areas on which the plant occurs the flower stalks begin to show about July 10, and by August 5 nearly all have been sent up. Matured seeds are usually not found before August 25.

The viability of the seed crop has not been determined. Other species of the same genus growing in similar habitats have given results that are comparatively low. (See Table 2, p. 58.)

The forage value of *Juncus parryi* is not especially high, resembling that of elk grass more than any of the other species described. Like the latter, this rush is eaten to some extent early in the season, but soon becomes extremely tough and unpalatable. For this reason, if other forage is available, it remains untouched by horses and sheep. Since it is grazed to such a limited extent, practically nothing is known of its nutritive qualities.

A number of other rushes of minor importance occur throughout the mountains, the majority in moist soils.

Wood Rush.

(*Juncoides parviflorum.*)

This genus is closely related to the rushes and resembles them in general character. It may be distinguished from the latter, however, by the leaf sheaths, which in this genus are closed and in the rushes open. Further, the seed vessel or capsule of *Juncoides* bears 3 seeds while in *Juncus* the capsule is many-seeded. About 60 species are on record and they are widely distributed.

Wood rush is a tufted, hardy, perennial plant, the stems, commonly 2 to 3 in a tuft, 1 to 2 feet high. As shown in Plate XXXIV, the grasslike flat leaves, usually about one-third the length of the flower stems, are wide and sharp-pointed; inflorescence a loose panicle, commonly $2\frac{1}{2}$ to 4 inches long, its lowest bract foliaceous, usually less than $\frac{1}{4}$ the length of the panicle; flowers borne singly or 2 to 3 together on the branches of the panicle on slender pedicels or stalks.

Wood rush is strictly a high-range plant, and while found to a limited extent in the warmer situations of the Arctic-alpine zone it is almost entirely confined to the Hudsonian zone. The densest and most luxuriant growth occurs in the semihumid soils of exposed situations, though it is often found in considerable abundance both in well-drained soils and on forested areas. Its most common associate is tufted hair-grass (*Deschampsia caespitosa*) and black hair-grass (*D. atropurpurea*). In water requirements it is similar to the two species of hair-grasses, neither of which may be classed as highly drought resistant. It is usually unable to recover from a wilted condition in its natural habitat when the water content of the soil drops to between about 10 and 12.5 per cent.

Since the plant grows only on the higher and relatively moist soils, the flower stalks seldom begin to show until July 20. Three weeks later practically all have been produced. Matured seeds are found about the time that the last flower stalks are sent forth, though the

F-35Q

MOUNTAIN ONION (ALLIUM VALIDUM).

F-36Q

SMALL WILD ONION (ALLIUM COLLINUM).

main seed crop is not ripened until about September 1. The vitality of the seed, according to tests made in 1908–1909, is low, an average for the two seasons giving only 7.5 per cent. The plant regenerates vegetatively to a marked degree.

No local species of the family to which wood rush belongs compares with it in forage value, in which respect it is of much more importance than certain species of grasses. It is relished by all classes of stock, but because of being restricted to high mountain lands not usually accessible to cattle and horses it is grazed almost entirely by sheep. The relatively moist and cool soil which it characteristically occupies tends to prevent rapid early spring growth, such as is made by plants in the better-drained and warmer habitats. Wood rush is therefore eaten with avidity when other species of high repute, as forage plants, are well along towards maturity and eaten with little gusto. Both sheep and horses have been observed to graze the leaf blades with eagerness, in preference to certain grasses and forage weeds, late in September.

Wood rush is able to withstand an unusual amount of trampling and abuse in favorable habitats because of its density of growth. This is due not to a particularly deep-root system, but rather to the density of the roots which ramify through the superficial soil layer, binding it so firmly as to prevent exposure of the roots by trampling.

NONGRASSLIKE PLANTS.

Besides the grasslike plants included in the preceding discussion, there are a number of other plants which furnish a large amount of the most valuable forage on the upland ranges. All classes of stock prefer a variety of feed, and sheep probably utilize a greater number of species than any other class. During certain periods of the year and under certain conditions, even where there is an abundance of comparatively palatable grasses, their choice forage is made up almost wholly of weeds and browse. A band of sheep when passing somewhat hastily over a range which supports an admixture of grasses, sedges, rushes, weeds, willows, elders, and the like, first eat the tender weeds and leaves of shrubs, while the grasses are not grazed, except to a limited extent, until the other kinds of forage have been largely consumed. On many of the upland ranges on the Wallowa National Forest there is a superabundance of weeds and here and there a number of shrubs, and since these ranges are accessible in the main only to sheep, the areas supporting these nongrasslike species are very closely cropped.

Owing to the great variety of this class of feed and the large number of species grazed by sheep, only the species of first importance are discussed. These have been arranged in families and according to their botanical relationships.

Liliaceae.....Lily.
Allium validum.
Allium platyphyllum.
Allium fibrillum.
Melanthaceae.....Bunchflower.
Veratrum viride.
Salicaceae.....Willow.
Salix scouleriana.
Polygonaceae.....Buckwheat.
Polygonum phytolaccaefolium.
Geraniaceae.....Geranium.
Geranium viscosissimum.
Onagraceae.....Evening primrose.
Chamaenerion angustifolium.
Apiaceae.....Parsnip.
Ligusticum oreganum.
Polemoniaceae.....Phlox.
Polemonium pulcherrimum.
Vacciniaceae.....Blueberry.
Vaccinium membranaceum.
Menthaceae.....Mint.
Agastache urticifolia.
Scrophulariaceae.....Beardtongue.
Pentstemon procerus.
Caprifoliaceae.....Honeysuckle.
Sambucus melanocarpa.
Sambucus glauca.
Valerianaceae.....Valerian.
Valeriana sitchensis.
Cichoriaceae.....Chicory.
Hieracium cynoglossoides.
Agoseris glauca.
Asteraceae.....Aster.
Rudbeckia occidentalis.
Achillea lanulosa.
Senecio triangularis.
Senecio columbianus.

Mountain Onion.

(*Allium validum.*)

Onions belong to the lily family. About 275 species have been described, and 40 or more are found in the western United States.

Mountain onion, an account of its abundance, size, and the relish with which it is eaten, is one of the most valuable of these plants. It usually attains a height of 1 to 2 feet. The bulbs differ from those of other local species in being narrow and much elongated. They are provided with a rose-white, delicate covering. The rootstocks are unusually stout, and the plant makes a bunched growth, producing a heavy, dense rose-colored or nearly white flower cluster (Plate XXXV). Mountain onion is restricted to the Hudsonian and timberline regions. It belongs to the group of plants which require a moist or even wet soil throughout the year and occurs in wet meadows and springy places within the altitudinal limits of its range. The

F-37Q

FALSE HELLEBORE (VERATUM VIRIDE).

F-38Q

FIRE WILLOW (SALIX NUTTALLII).

One leaf is turned so as to show the venation and character of the under surface.

minimum soil moisture content capable of maintaining it was found to be between 14 and 16 per cent. As a usual thing this plant grows in close association with marsh sedges and rushes, though it frequently produces a dense growth that crowds out other species.

The flowers begin to unfold during the first week in July, and nearly all are out by the end of the first week in August. Unlike grasses, whose pollen is carried to the flower by the wind, flowers of this and other onions obtain their interchange of pollen mainly through the visits of insects. The seeds are comparatively late in maturing, seldom beginning to ripen before the last week in August, and unfavorable weather conditions often prevent ripening. The average germination of the seed crop in 1908 and 1909 was 37 per cent. Considering the lateness of the maturing period, these figures are above the average.

The palatability of the mountain onion as compared with that of other plants growing with it is pronounced. When sheep first visit an area containing this particular onion in association with sedges, rushes, and the usual plants of such habitats, the majority of the other species are almost wholly disregarded until the onions have been grazed off. Few, if any, of the marsh plants are eaten with more eagerness than mountain onion. The flowers are usually cropped first, but the long flat tender leaves are apparently consumed with about the same relish.

Several species of onion occur on the upland ranges, but they furnish only a small amount of the range forage, though eaten greedily by nearly all classes of stock. Of these species the small wild onion (*A. fibrillum*) is the most important. This is the earliest of the species, doubtless from the fact that it is almost entirely confined to scablands. It is a small plant (Plate XXXVI), usually not over 6 inches in height, and has a cluster of white flowers which are expanded shortly after the disappearance of the snow. It is valuable only as an early range plant, and by August 1, like most other onions in similar situations, completes its growing period, dries up, and disappears. Wild onion (*A. platyphyllum*) is another important high mountain form, very similar economically and ecologically to *A. fibrillum*.

One objection to grazing sheep upon onion is that the mutton is flavored by it. This objection is not serious, however, since the plants are usually grazed early in the spring when there is little or no output of mutton, and the flavor is soon lost when sheep are put upon other forage.

False Hellebore.

(*Veratrum viride.*)

False hellebore, sometimes known erroneously as skunk cabbage, is a close relative of the lilies. In appearance it resembles the true hellebore (*Veratrum album*), from which it derives its common name.

False hellebore is a perennial herb, 1½ to 6 feet tall. Just beneath the ground the stalk becomes fleshy and much expanded, and from this protrudes a number of rootstocks and from 35 to 40 coarse, "ropy," tough roots, the latter penetrating the soil to a depth of about 20 inches. The stem is very stout and has an abundance of short-petioled or sessile, acute and broad leaves; the panicle is elongated, drooping, and provided with a profusion of green flowers (Plate XXXVII).

False hellebore flourishes best in a comparatively wet soil. It grows densely in marshy basins, along creek banks, and in swales of nearly all kinds in the upland ranges of the Hudsonian zone. It wilts notably, in most cases beyond recovery, when the soil water content is reduced to from 11 to 14.5 per cent. The flower stalks rarely put in their appearance until about August 5, and in certain places the flowers do not unfold until September 1. The lower flowers expand first, and the lower part of the panicle is the first to mature the seed. Dissemination takes place shortly after maturity, and since the seeds are flat, broad, and winged, they are well scattered. The earliest seeds to ripen in 1909 (about August 25) showed an average germination of 24 per cent. Those which matured after September 5 had practically no viability.

The forage value of false hellebore varies with the time of year, though in a way opposite from that of most grazing plants. Except very early in the spring, prior to the expansion of the leaves, when the young shoots are grazed by sheep to a certain extent, it is seldom eaten until after one or two rather severe frosts. Usually not until after August 15 is any considerable portion of the plant grazed with much relish on upland ranges, but later in the fall sheep eat it. In many instances only 3 or 4 inches of the coarse stalk is left. The leaves and pithy portion of the stalk are the parts relished.

Stockmen generally hold that this plant is poisonous if eaten before it has been frosted. To what extent false hellebore has a toxic effect on stock early in the season is not known, but no authentic cases are on record where sheep have been poisoned by it. The short rootstocks are no doubt poisonous, but late in the season, at the time when the plant is generally grazed, the roots are rarely pulled up.

Fire Willow.

(Salix scouleriana.)

In the region studied the willow family, including poplars or aspens, furnish more first-class browse than any other group. Fire willow, or Nuttall's willow as it is sometimes called, is a common invader of burned-over lands, where it is the most important species.

F-39Q

WILD BUCKWHEAT (POLYGONUM PHYTOLACCAEFOLIUM).

F–400

GERANIUM (GERANIUM VISCOSISSIMUM).

A portion of the coarse root is shown on the left.

Fire willow rarely develops into tree form in the region studied, though elsewhere it often attains a height of from 15 to 25 feet and a diameter of 8 inches. The leaves are of a light shade beneath, smooth, and free from hairs on the upper surface. The midrib is prominent and yellow (Plate XXXVIII).

This willow grows along mountain streams, in canyons, and on gentle slopes in damp leaf litter or rather poorly disintegrated soils. While it is sometimes sparsely scattered it more often grows in dense clumps. On burned-over areas in canyons and on gentle slopes where the soil has not been rendered sterile, it often produces dense low thickets. On the Wallowa National Forest where it grows in close association with snow bush or buck brush (*Ceanothus velutinus*) in the Canadian zone, it forms what is known as chaparral. In the Hudsonian zone it occurs more sparingly.

Male and female flowers are borne on different bushes, the seed production, of course, being confined to the female ones. The seeds ripen in the spring about the time the leaves have reached full development. The little pods open up soon after maturity and liberate the silky hairy seeds, which are widely distributed.

No tests were made of the viability of the seed of this species. It produces an abundance of seed, but reproduction is mainly vegetative.

In the Wallowa Mountains fire willow is the preeminent browsing plant. The low and spreading habit of growth adds greatly to its value as a sheep forage, and the time at which the leaves are developed renders it valuable as an early browsing plant. As high as sheep can reach, the branches are stripped of their leaves, though the bark is seldom eaten. Since this plant makes a comparatively rapid growth, a portion of the branches are soon beyond the reach of sheep and injury from severe grazing is unusual. In fact, the more sheep browse on the willow the denser becomes the growth. This is due to the vigorous and persistent sprouting of new branches as a result of the trimming back of the young shoots through grazing. Even when a bush is cut to the ground a number of young shoots are produced.

Wild Buckwheat.

(*Polygonum phytolaccaefolium.*)

This plant belongs to the well-known buckwheat family; the genus is represented by some 70 species in the United States.

Wild buckwheat is a perennial with a coarse, fleshy, sparsely branched but deep root. It attains a height of about 2 feet; the stem is well supplied with comparatively large, oval-shaped leaves, and panicles of rather small greenish white flowers (Plate XXXIX).

The species is mainly confined to exposed situations in the Hudsonian zone, though it occurs to a limited extent in both of the bordering zones. It attains its best development on mountain

slopes in a soil with the average amount of moisture.[1] While it seldom grows pure, it is common enough in mixture with grasses of various kinds to give character to the range.

Flower stalks appear from about the latter part of the second week in July until August 5. Matured seeds are found as early as August 1, while the major part of the crop is matured by about August 25. Though the seed crop is ripened early the vitality is not high. The average germination obtained in 1908 and 1909 was 3 and 13.5 per cent, respectively.

Since wild buckwheat inhabits comparatively dry situations, it resumes growth early in the spring and by July 15 has produced an abundance of leafy herbage which is greedily eaten by sheep. After about the last 10 days in August, when the leaves begin to dry up, the plant is no longer relished. In many places where the natural reseeding experiments are being conducted good reproduction of this species has been secured. It withstands trampling remarkably well, and is promising as a plant for the revegetation of depleted ranges under a system of deferred grazing. The nutritive qualities of wild buckwheat are generally considered to be high.

Geranium.

(*Geranium viscosissimum.*)

Geranium belongs to the same family as the well-known alfileria or "filaree," which is so valuable for grazing in certain sections of the country. It is a coarse, much branched, and leafy species (Plate XL), from 1 to 2 feet high. Both the branches and the upper side of the leaves are covered with fine hairs; the leaves are long petioled, large and thick, deeply three-parted; the petals pink or purple, sometimes fading to barely white. The root is very coarse and tough, and rather deep, but not branching.

In the Transition zone this plant is sufficiently abundant to be of considerable value for grazing, and is nearly as common in the Canadian zone, occupying open glades and parks and canyon bottoms and hillsides, in medium moist, preferably gravelly, loam soils rather rich in humus. It rarely grows in dense stand, but in favorable situations is often conspicuous, especially during the flowering period. It is usually associated with Indian paint brush (*Castilleja*) and yarrow (*Achillea*).

The flowering period extends over approximately one month. On the lower ranges it is among the first of the perennial plants to bloom.

[1] In determining the water requirenents of this species, it was almost impossible to obtain reliable data by the methods used because of the deep "taproot" which, if only slightly injured, would result in death to the plant within a few hours. An average of all tests attempted showed that it was unable to absorb water at a rate sufficient to reestablish turgidity from the soil in which it grows when the content was reduced to between 8 and 10 per cent. Judging from the species with which it is associated and the habitat in which it grows, these figures appear to be somewhat high.

F-41Q

FIREWEED (CHAMAENERION ANGUSTIFOLIUM).

F-420

WILD CELERY (LINGUSTICUM OREGANUM).

In the Canadian zone the flowers begin to unfold about June 20, and by July 20 most of them have expanded. The seed matures from about July 25 to August 15. In 1909 the seed crop from the Canadian zone germinated 29.5 per cent. Reproduction on the range in general is taking place slowly.

Geranium is one of the choice forage plants for cattle and sheep. Since it grows in abundance on the cattle and sheep allotments, it is equally valuable to both classes of stock. When it is young all but the lower portion of the coarse stem is eaten, but later only the flowers, immature fruits, and leaves are grazed. About the time that the seed crop has matured the leaves dry up and the plant loses much of its forage value.

Fireweed.

(*Chamaenerion angustifolium.*)

Chamaenerion angustifolium is given its name, fireweed, because of its prevalence on burned-over forest lands. This species is the most valuable perennial grazing plant of the evening primrose family. It attains a height of 2 to 5 feet, depending on the situation. The cylindrical stem bears an abundance of long, slender, nearly entire, thin leaves, and the inflorescence consists of a raceme of delicately pink or nearly white, or sometimes purple, flowers developed at the apex of the stem (Plate XLI). The long, slender capsules split into four divisions at maturity, liberating the numerous minute seeds provided with a tuft of long silky hairs, by means of which they are carried great distances by the wind.

In the Wallowa National Forest fireweed is most abundant on burned-over areas in rather dry, often coarse, gravelly and even sterile soils in the Canadian zone. It also occurs in both of the contiguous zones, though never in pure stand. It is one of the first species to invade heavily burned lodgepole-pine forests.

Fireweed is drought resistant, comparing in this respect with some of the grasses which grow both in moist and in dry situations. The plants were found not to wilt excessively until the soil moisture was reduced to between 8.2 and 11.5 per cent, depending upon the particular soil type. In the moister places, where decayed vegetable matter is more abundant, the moisture requirement figures are higher.

The production of flower stalks, like the seed-maturing period, continues for an unusual time. In the warmer situations flowers begin to unfold as early as June 20, and in a few places buds are found at the apex of the raceme as late as the early part of August. The lower flowers are first displayed, and as the season advances there is a gradual sequence or succession in the flowering toward the

apex of the raceme. Accordingly, while the upper part of the raceme is in full flower the lower portion often has well-developed seed pods. In some cases the seed reaches maturity on the lower parts of the raceme while buds are still forming on the upper portion. The seed-maturing period begins about August 1 and continues until inclement weather sets in.

While the viability of the seed is not high, the average for that collected in 1908 and 1909 being 21.5 per cent, the earlier maturing seed runs from 10 to 12 per cent higher than that maturing later. The amount of seed produced is unusually large and reproduction is very abundant.

When young, fireweed is eaten with great avidity. As the season advances, however, the stem become fibrous and unpalatable, and after August 1 only the flowers and leaves are grazed, the stem being left quite naked. Few if any "weeds" are more relished by sheep than fireweed. Horses, too, eat it to a limited extent, and cattle graze it ravenously. Since it begins growth early in the spring and is late in reaching maturity, it furnishes a much relished feed during the greater part of the summer grazing period.

Wild Celery.

(*Ligusticum oreganum.*)

Ligusticum oreganum, sometimes called wild parsnip, belongs to the same family as cultivated celery, parsnip, and carrot, and in the region studied is called both wild celery and wild parsnip. It has the characteristic parsnip aroma, and resembles the parsnip somewhat in the appearance of the leaf (Plate XLII). It should not be confused with the poisonous water hemlock, which is found in wet soils and is sometimes called "wild parsnip."

Wild celery is a smooth perennial with large aromatic, sparsely branched roots. The leaves are numerous, nearly all basal, and compound, being ternately (in three) then pinnately divided; the umbel is made up of numerous rays with many narrow pointed bracts surrounding the flower cluster.

The plant is distinctly one of the Hudsonian zone. It occurs on all exposures and slopes, but prefers deep, loose, porous and friable, well-drained soils of medium moisture content. Since it does not regenerate by offshoots from running rootstocks, it probably is not capable of forming, even under most favorable conditions, pure or nearly pure stands. It is most commonly associated with mountain bunchgrass, short-awned bromegrass, and other species inhabiting the better soils or glades. Its water requirements are higher than those of its associates. The plant wilts usually beyond recovery in a soil whose water content varies from 8 to 9.5 per cent.

F-43Q

SKUNK WEED (POLEMONIUM PULCHERRIMUM).

Only a portion of the creeping rootstock is shown.

F–44Q

HIGH HUCKLEBERRY (VACCINIUM MEMBRANACEUM).

Showing edible mature berries.

The leafless flower stalks begin to show about the second week in July, and are nearly all developed during the succeeding four weeks. The seed crop matures, on the average, from about August 15 to September 10, and is disseminated immediately afterward.

The seed has low viability. In 1907 and in the two succeeding seasons a germination of 2, 6, and 11.5 per cent was obtained. The plant, especially the fruiting parts, is very sensitive to frost, which may account in part for the low viability of the seed, since after August 15 frosts are frequent in the situations where it grows. Reproduction is taking place sparingly on the range in general, and even on the allotments that are in process of reseeding under deferred grazing.

Wild celery may be utilized quite as early for grazing purposes as the majority of the grasses, and furnishes ideal feed for sheep from July 20 to August 25. Horses sometimes eat it, though only to a limited extent. Unlike most plants, it is eaten with quite as much relish late in the season as early in the summer. After about August 25 it is not valuable for forage, the leaves being killed by frost, leaving only the naked flower stalk.

Skunkweed.

(*Polemonium pulcherrimum.*)

Skunkweed, so called because the plant has an odor somewhat suggestive of a skunk, is a fine hairy plant from 4 to 8 inches in height, with sparingly branched slender stems. The leaves are basal and compound, the oblong leaflets numbering from 7 to 15 or even more. The corolla of the clustered flowers is blue, turning very pale or nearly white before dropping. The root system is exceptionally superficial and spreading (Plate XLIII). The plant grows in tuftlike patches of shoots arising from creeping rootstocks. If a single plant is pulled from the ground in a loose soil most of the lateral roots, as well as the main root, come up with it.

Skunkweed is confined almost exclusively to the Hudsonian zone. While it often produces a conspicuous and luxuriant growth in the open, it prefers the somewhat diffuse light of open forest lands. In exposed situations, where the soil type is relatively coarse in texture, the plant does not succumb from excessive transpiration until the soil-water content is reduced to 7 per cent, and in protected situations, where the soil texture is rather fine, death due to wilting comes when the water content is reduced to 10 per cent.

The flowers begin to open during the second week in July and bloom throughout August, though after the middle of the month most have expanded. About August 20 the seeds begin to ripen, and this continues as long as the season is favorable. The seed crop

is comparatively fertile. In 1908 and 1909 an average germination of 41.5 and 32.5 per cent was obtained.

Since skunkweed grows above the range ordinarily grazed by cattle, it furnishes only sheep forage. It is eaten ordinarily with about the average amount of relish, and at times ravenously. It is best for grazing purposes from about July 20 to the last week in August. At the latter end of the season the foliage is frequently frostbitten and dry.

High Huckleberry.

(*Vaccinium membranaceum.*)

High huckleberry is the most valuable grazing species of its family in the region studied. It is a much branched and leafy shrub from 1 to 4 feet tall (Plate XLIV), the twigs slightly angled, leaves thin, not shining, short-petioled. The flowers are inconspicuous and solitary, and the corolla, usually five-toothed, is greenish or purplish in color. The berry, when mature, is purplish black. It is slightly acid and is highly valued as food.

High huckleberry is confined to the Transition and Canadian zones, being most abundant in the latter. It is commonly found under yellow pine, fire willow, and lodgepole pine, and accordingly endures a considerable amount of shade. It is characteristic of strongly acid or sour soils, and is rarely, if ever, found on limestone or even neutral soils.

On the lower elevations the flowers begin to appear about June 1, and by July 1 most of them have expanded. The berry begins to develop dark pigment as early as July 15, and the ripening period continues until about the first week in September, at which time most of the berries are clinging. Since the berries are palatable to both birds and animals, they are almost entirely consumed, and seed distribution is thorough.

Sheep browse this plant with avidity, and it is grazed from about June 15 to late in the autumn, though it is most palatable early in the season.

Throughout the Canadian and Hudsonian zones and up to the limits of tree growth another species, known as red huckleberry (*Vaccinium scoparium*), occurs in even greater abundance than the high huckleberry. As a forage plant, however, it does not compare with the latter, though it is grazed to a limited extent. This species also is confined to acid soils.

Horsemint.

(*Agastache urticifolia.*)

Horsemint is the most widely distributed representative of the mint family in the Wallowa Mountains, and is of the highest value for grazing.

F–45Q

HORSEMINT (AGASTACHE URTICIFOLIA).

F—46Q

BLUE BEARDTONGUE (PENTSTEMON PROCERUS).

A portion of the running rootstocks is shown.

It is an erect smooth perennial plant from 1 to 3 feet tall, with square stems and opposite, petioled leaves, the margins coarsely and irregularly toothed. The flowers are clustered in a dense terminal spike, the corolla pink-white or sometimes light purple. The root is coarse, fibrous, woody, and rather spreading (Plate XLV).

Horsemint is widely distributed. It is met with occasionally in the Transition zone, and is abundant in the Canadian and Hudsonian zones. Though occurring but sparingly in the upper altitudes of the latter zone, it is of considerable value for forage up to 8,000 feet. The best development and densest stands are found in loose soils of medium moisture on the glades in the upper Canadian and lower Hudsonian. While it often predominates over associated species in the better and moister soils, it almost always grows in scattered stands, especially in shallow, coarse, gravelly clays.

The flowers begin to form about July 10, but all are not expanded as a rule until August 20. Fertilization is largely effected through insects, mainly bees. The two-lipped corollas drop soon after fertilization.

Matured seeds are usually found by the last week in August though the entire crop is rarely ripened until about September 10. The matured, brownish-black, plump, hard-coated, oval seed-like nutlets are not disseminated at once, but are readily expelled when the seed cluster is vigorously shaken, shooting out some distance from the parent plant. For a high-range plant the germination power of the seed is about the average. In 1908 and 1909 representative samples gave an average of 16 and 28.5 per cent, respectively. Where this species is given a chance to reproduce, i. e., on ranges where the seed crop is allowed to mature prior to grazing, reproduction is taking place, though sparingly. The actual amount of seed produced per plant is relatively small, and since only about one-fourth is fertile the species is succeeding as well as might be expected.

Horsemint begins growth early in the season and matures late and consequently is relished by stock at all times during the summer. Both sheep and cattle eat it with much relish, though sheep graze it with greater avidity. Horses eat it only to a limited extent, and it can not be considered of value for this class of stock. Until the flowering parts begin to drop the entire cluster is consumed, so that early in the season the whole plant is eaten. After about August 10 only the leaves are grazed. Since younger leaves remain green some little time after seed maturity, horsemint is preferred in the fall of the year to some of the more valuable grasses and forage plants.

Blue Beardtongue.

(*Pentstemon procerus.*)

About 100 species of *Pentstemon* are found in the United States and Mexico, many of them of value for grazing. Blue beardtongue

is the most highly relished as well as the most abundant of the various species on the high range lands of the Wallowa National Forest.

Blue beardtongue is a perennial with conspicuous lateral running rootstocks which send out a number of shoots reaching a height of 4 to 12 inches. The whole plant is smooth and somewhat shiny; the lower leaves are long petioled, smaller than those arising from the middle of the stem; the upper leaves are small and without leaf stalks (Plate XLVI). Thee flowers, usually 5 in a cluster, are arranged in whorls. The bright blue corolla is lipped, the lower lip bearded within. As in all beardtongues, one of the five stamens is sterile, and in this species it is distinctly bearded also.

This plant is conspicuous in the Hudsonian zone, though it grows in varying abundance at lower altitudes. Open parks and medium moist meadows of deep, loose, but well-drained soils are the favorite habitats. In moisture requirement it resembles wild celery (*Ligusticum oreganum*), with which it is commonly associated. In the characteristic soil type in which blue beardtongue grows, wilting beyond recovery does not occur until the soil-water content is reduced to from 10 to as low as 8 per cent.

The flowers begin to open about July 10, and all are out by August 15. About the time the last flowers expand the first matured seeds are found, though, of course, on different plants. The seed tested in 1909 showed a viability of 18.5 per cent. In previous years no germination studies were made. Under favorable conditions on protected ranges, however, reproduction is excellent, and it is apparent that this plant will increase in abundance under the deferred-grazing system.

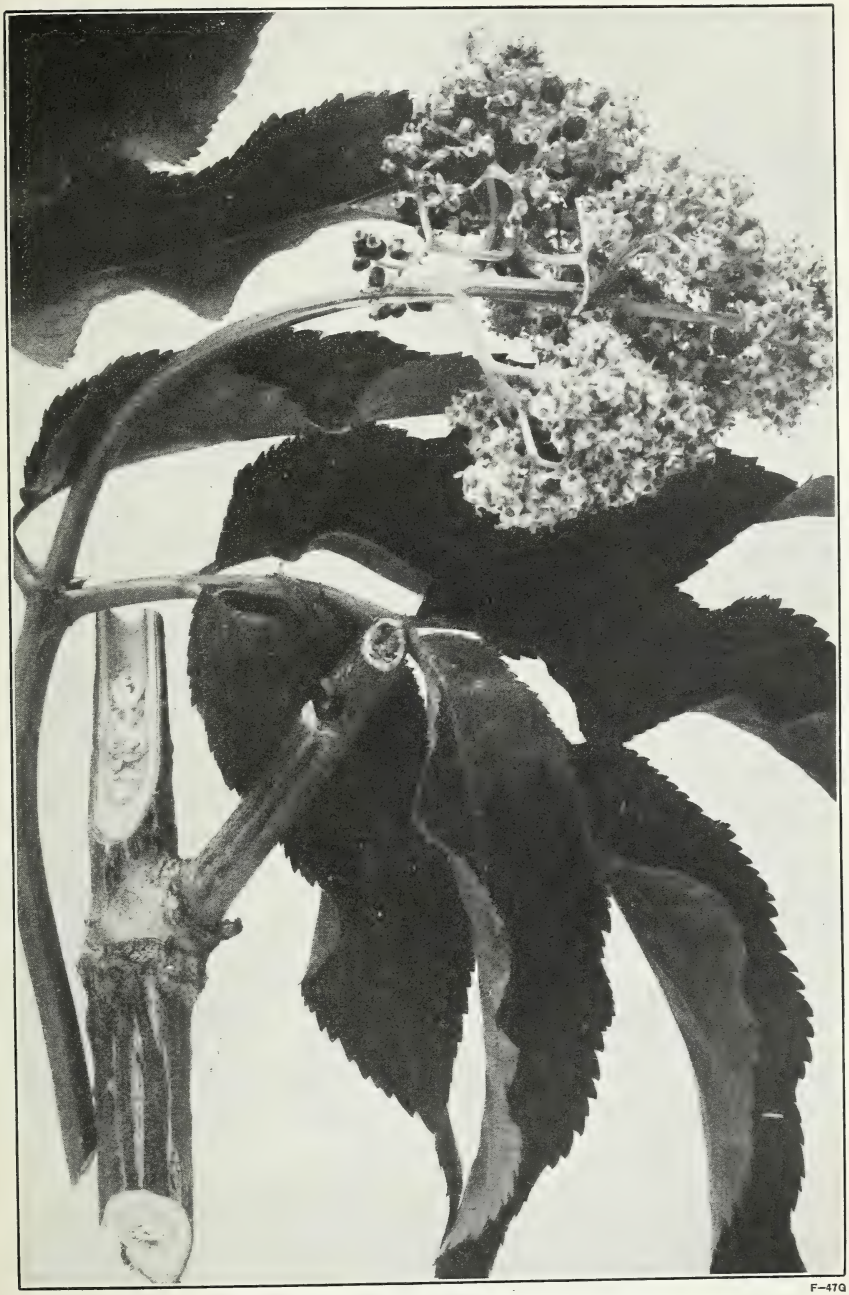
Blue beardtongue seems to be eaten by sheep with more eagerness than any of its allied species. Since its growth begins promptly in the spring, it furnishes a fair portion of the valuable early forage. The leaves, but not the stems, are eaten even after the seeds have matured, though they are not as palatable as earlier in the summer. The plant is of highest value for grazing between about July 15 and August 20.

Besides the blue beardtongue three species of *Pentstemon*, *P. deustus*, *P. fruticosus*, and *P. venustus*, all grazed at certain times in the season, are common in the Wallowa Mountains.

Mountain Elder.

(*Sambucus melanocarpa.*)

Mountain elder is a shrub with stems 3 to 6 feet high rising in profusion from a common crown; twigs of one year old growth smooth, shiny green-brown and slightly angled, the pith yellow-brown; bark of the older branches rather thick, rough, dark yellow-



F-47Q

MOUNTAIN ELDER (SAMBUCUS MELANOCARPA).

Observe the smooth bark of the young twig in contrast to the coarse bark of the older branch.

F–48Q

MOUNTAIN ELDER (SAMBUCUS MELANOCARPA).

Because of the palatability of mountain elder, sheep usually leave the lower branches quite bare of foliage.

Dead clumps of mountain elder are often found on the range. Since the species is comparatively short lived this condition may be due, in part at least, to age.

brown; leaflets 5 to 9, smooth or slightly hairy, light green on the lower side. As shown in Plate XLVII, the flower clusters are convex, as broad as high, the flowers white, fruit shiny black, without bloom. In the lower elevations this species is associated with blue elder (*S. glauca*), which is readily distinguished by the white pith in the year-old stems, the treelike form of the older plants, the flat-topped flower clusters and the chalky bloom on the black berries which gives them a bluish appearance—thus the name blue elder.

Mountain elder is most abundant on hillsides, in the bottom of mountain canyons, in ravines, and along brooks and mountain streams in fertile, friable, gravelly soils of varying degrees of moisture. It occurs in the Transition and Hudsonian zones, but is more abundant in the Canadian, often in association with ninebark (*Opulaster pauciflorus*), western larch, Douglas fir, and open stands of lodgepole pine. It prefers open situations, though partial shade does not prevent luxuriant growth.

The attractive white-flower clusters begin to show about July 15 on the higher ranges, and earlier on the lower ones. About September 1 most of the berries have reached full development. These are eaten by birds and a few mammals, a wide dissemination of the seeds being thus insured. No germination tests were made of this species, but observations on the range show that it is reproducing well.

As a browse it is as valuable, though not nearly so abundant, as willow. In localities where the two are associated elder is browsed first. Because of its low branching habits and the unusual relish with which it is browsed there is danger of mountain elder being eaten too closely. A common example of such a condition is shown in Plate XLVIII.

Mountain elder is also highly relished by sheep and is grazed with relish at times by cattle. It occurs mainly in the Transition zone, but never in great abundance, and therefore is not highly important as a browsing plant.

Valerian.

(*Valeriana sitchensis.*)

Valerian is one of the most characteristic plants on old burns in the Hudsonian and upper Canadian zones where the soil has not been rendered sterile and the moisture conditions are about average. It is a perennial and attains a height of from 1 to 2 feet; the stem is slender with usually three pairs of pinnately compound leaves, the lower long-petioled (Plate XLIX). The flower cluster is dense and contracted, the corolla tubular and pinkish white; from the woody,

horizontal, creeping rootstocks long fibrous roots are developed. The rootstock is peculiarly aromatic.

Valerian prefers a rather porous, somewhat gravelly, and comparatively deep fertile soil, but does not require a large amount of moisture, as it made average development in such soil where the minimum water content was only 9 per cent. Destructive wilting came, however, when the water content was reduced to between 7 and 8.5 per cent.

The plant begins to flower profusely about July 15, and by August 15 nearly all the flowers have expanded. The seed crop matures from August 20 to the close of the season, some individual plants never reaching maturity. The early-maturing seed in 1908 and 1909 germinated 21.5 and 26 per cent, respectively. On protected ranges reproduction is taking place sparingly.

Both cattle and sheep are very fond of valerian at nearly any time during the summer, but it grows in greatest abundance on the sheep ranges. On burns covered with dead and down timber sheep search for it and graze it quite as readily as the fireweed, with which it is commonly associated. Early in the season the flowers, leaves, and lower portion of the stem are consumed; later in the summer only the flowers and leaves are eaten.

Mountain Dandelion.

(*Agoseris glauca.*)

Mountain dandelion, so called because of its abundance on the upland ranges and similarity in appearance to the ordinary dandelion, is a milky-juiced perennial from 4 to 8 inches high. In loose soils it has a sparsely branched taproot, which penetrates to a depth of 1 to 2 feet, but in rocky soils the root is usually branched. The oblong basal leaves, generally tapering to the apex, are smooth and somewhat shiny, while the flower stalk, about a third longer than the leaves, is covered sparsely with coarse hair (Plate L). The solitary head of yellow flowers is borne at the summit of a naked stalk; the mature seeds bear a crown of copious, slender, simple, white, bristle-like hairs.

While this species occurs to a limited extent on the lower ranges, it is much more abundant on the grazing lands in the Hudsonian zone. On open plateaus and well-drained glades of loose, gravelly, deep, clay loam it grows most luxuriantly. It is fairly drought resistant, not wilting excessively in the finely disintegrated soil in which it naturally occurs until the soil-water content is reduced to from 8 to 10 per cent. In favorable situations the stand is comparatively heavy, but ordinarily it is rather scattered.

The flower stalks begin to appear in the latter part of July, and by August 15 nearly all are in evidence. This is somewhat later than the

F–49Q

VALERIAN (VALERIANA SITCHENSIS).

F-58G

MOUNTAIN DANDELION (AGOSERIS GLAUCA).

Showing expanded flower and matured fruit not yet disseminated.

average. The seed crop, too, is produced late. A few matured seed heads are seen about August 10, but most of the seed reaches maturity in September, often in the latter part of the month. Fortunately this plant is very resistant to frost, and consequently the seed continues to develop after many other species, such as wild celery, have been killed.

The vitality of the seed crop, taking into account that produced both early and late in the Hudsonian zone, gave an average of 29, 38, and 41 per cent, respectively, in the three years of test. Mountain dandelion is reproducing comparatively well on the range, and promises to respond favorably to any system of protection which will allow the seed crop to mature.

Sheep seek the plant in preference to many grasses and weedy species. Each season it is eaten down to the ground, leaving only the coarse base. In the early part of the summer, and even until the seeds are nearly mature, the young, tender, juicy flower stalks, leaves, and even the flowers, are eaten with avidity. Few other species enjoy as long a growing season. In 1909 the leaves were still green and highly palatable to sheep on October 1. The seeds are usually not disseminated for a considerable time after maturity, but the hairy appendages which are the means of affecting their dispersal by the wind are not objectionable to stock.

Woolly Weed.

(*Hieracium cynoglossoides.*)

To see this peculiarly woolly plant, sometimes referred to as woolly hieracium, one would hardly think of it as valuable for forage. Sheepmen state, however, that the only objection is that it does not occur more abundantly.

It is from 1 to 2 feet in height with numerous leaves arising from the crown of the perennial, coarse and much-branched root, and an abundance of leaves on the stem. The dense covering of fine soft hairs on the stem and leaves gives it a very distinctive character (Plate LI).

It is unusual to find a dense ground covering of woolly weed. It grows almost invariably with other weedy perennials, such as mountain dandelion, blue beardtongue, and numerous grass species, among which it seldom predominates. In soil and moisture requirements it is almost identical with mountain dandelion. Individual plants wilted beyond recovery in soil varying in water content from 8 to 10.5 per cent. These figures are similar to those obtained in the case of certain bunch grasses with which woolly weed is associated.

The flower stalks are produced between July 15 and August 20, the greatest number being sent up after August 1. The seeds begin

to ripen about August 25, but owing to the late date of the flower-stalk production only a small seed crop is matured. In 1908 and 1909 only 9.3 and 12.5 per cent, respectively, of the seed showed fertility. From these figures and from observations on the range, it does not seem likely that a marked increase in the species can be effected by range protection and improved methods of handling.

If palatability and not abundance and distribution were taken into account, woolly weed would rank among the most important range plants. It is so closely grazed early in the summer that nothing but the root remains. The coarse and comparatively deep root system protects it from actual killing and under ordinary conservative handling of stock it may at least be expected to hold its own.

Coneflower.

(*Rudbeckia occidentalis.*)

Of the several valuable nongrasslike forage plants, coneflower, sometimes called "nigger head," is one whose actual grazing qualities are often underrated. It is a conspicuous plant, attaining a height of 2 to 5 feet, and having numerous marginally toothed, somewhat rough, ovate leaves, those lowest on the stem being petioled, and the upper ones sessile. Numerous shoots are sent out from the coarse, woody, fibrous perennial root, and the older plants have a bunched growth. This plant, as shown in Plate LII, is usually not branched, and the dense, rayless, oblong, brown head of flowers, resembling a cone, is borne at the apex of the stem.

The most common and favorable habitats of coneflower are the somewhat shaded banks, mountain swales, and hillsides where the soil is moist but not saturated. One of its most common associates is false hellebore, whose moisture requirements are almost identical. Coneflower is occasionally met with on open, well-drained glades, but never in abundance. In such habitats, in the characteristic basaltic clay loam soil of the region, wilting of all leaves did not take place until the soil moisture was reduced, on the average, to 14 per cent. In the richer soils, those which are heavily impregnated with organic matter, pronounced and long periods of wilting, usually followed by death of the plant, were recorded when the soil contained from 16 to 18.5 per cent water content.

Early in the season the "button" or flower head begins to develop and by August 15 has virtually attained full growth. The seeds, however, do not begin to ripen until about the last week in August the ripening period extending well into September, and the seeds remaining in the head until late in the autumn. The germinative strength of the seed crop in the three years of test was 16, 24.5, and 11, respectively. Even in the most favorable situations the seedlings stand is rather sparse, but reproduction from roots is abundant.

F-51Q

WOOLLY WEED (HIERACIUM CYNOGLOSSOIDES).

F-52Q

CONEFLOWER (RUDBECKIA OCCIDENTALIS).

Coneflower furnishes a large supply of forage. The stems are rather tough even when young, and only the flower heads and leaves are eaten. As the plant attains its full height the seed heads are generally above the reach of sheep. While in some localities the stems are quite bare after the lands have been grazed, this is rather the exception. In mixture with other palatable plants it is grazed with relish, but when it furnishes the bulk of the feed, stock are apt to scatter widely in search of more desirable forage.

Yarrow.

(*Achillea lanulosa.*)

Yarrow is one of the most widely distributed plants in the region studied. It is found from the lower Transition to the upper Hudsonian zone, on intermediate ranges in such abundance as to be of considerable grazing value throughout the mountains.

Wild tansy, as yarrow is sometimes called because of its resemblance and close relationship to the tansy cultivated in gardens, is a perennial with stems densely woolly, 12 to 24 inches high, terminating in conspicuous flower clusters, convex in shape, and with white ray flowers. The silky leaves, finely divided or dissected (Plate LIII), are produced in abundance, as are also the leaves which originate from the horizontal rootstocks.

This species while succeeding best in a comparatively light, well-drained clay loam, does well in a variety of soils and situations. It inhabits glades and open parks, however, where it gets the benefit of full sunlight. In the lower situations it is scattered, and it does not anywhere form a pure stand. On the upland ranges, however, it usually forms great bunches or tussocks, as shown in Plate LIV. It is comparatively drought resistant. Individual plants tested did not wilt to a point causing death until the moisture content was reduced to 12.3 in one case and 10 per cent in another.

The flowering period is unusually prolonged. On the lower ranges the flower heads begin to show early in June, but in the Hudsonian zone not until about July 20. In the mountain lands flowers which were just beginning to open have been observed as late as September 15. As a result, a large percentage of the seed crop in the high range never reaches maturity. The earliest fully ripened seeds are found about August 20. In 1908 and 1909 the germination tests averaged 16.5 and 39.2 per cent, respectively. Over 90 per cent of the seed crop of 1909 from the lower ranges was fertile. On protected range areas reproduction is very promising.

Both cattle and sheep seek out yarrow from among its associated species and eat it with avidity. As a rule the unpalatable stems are

deprived of their attractive flower heads and leaves early in the season. Sheep prefer the plant to many abundant grasses, even during the period when the latter are most palatable.

Butterweed.

(*Senecio triangularis.*)

Senecio triangularis is not only the largest and most abundant of the butterweeds in the region studied, but also the most palatable. It grows from 2 to 5 feet tall, and has a leafy stem which terminates in dense clusters of 20 or 30 bright yellow flowers. The leaves are all petioled and toothed. Shoots are sent up in abundance from the lateral running rootstocks (Plate LV).

Butterweed is closely confined to the higher ranges, being abundant in the upper Canadian zone and throughout the Hudsonian zone. It is distinctly a marsh plant and is closely restricted to situations with wet or saturated soils. On creek banks, in the vicinity of springs, and in swales of various kinds, it is often the chief plant. It was found to wilt beyond recovery in a soil whose moisture content varied from 11.5 to 14 per cent.

Usually the flowers do not begin to appear until about the last week in July, and the blooming period continues until the last week in August. The seed crop begins to reach maturity when the late flowers are unfolding. The ripening period continues until inclement weather, the latest flowers failing to mature seeds. The seed which had ripened by September 5 germinated, in 1908 and 1909, 18 and 26 per cent, respectively. The later maturing seed has a notably lower viability.

Early in the year butterweed is eaten with such avidity that almost nothing is left. Until August 1 the lower part of the stem is the only portion not consumed. As the season advances, however, only the flower clusters, the upper rapidly growing terminal part of the stem, and the leaves are grazed. Among late forage plants, butterweed is one of the most highly relished. Since it is found only in moist situations, however, its amount is limited.

Another butterweed much relished by sheep is *S. columbianus*, often called small butterweed. In the Wallowa National Forest this species occurs in scattered stand on well-drained soils throughout the Canadian and Hudsonian zones. It begins growth early and is of value for grazing only in the spring. Sheep prefer it to grasses, and eat it with such ravenousness that it has little opportunity to reseed under the usual grazing practice. Its relatively small size (Plate LVI), different habitats, and earlier flowering period, easily distinguish it from *Senecio triangularis*.

F-53Q

YARROW (ACHILLEA LANULOSA).

F-54Q

CHARACTERISTIC BUNCHED GROWTH OF YARROW ON UPLAND RANGES.

SUMMARY.

ECOLOGICAL REQUIREMENTS.

The figures given in Table 2 represent the relative water requirements of the different important forage plants studied.[1] Owing to the importance of having the plants advanced to as nearly the same point of development as possible when the drought tests were made aerial conditions were slightly different. The error due to this fact, however, is very largely offset by the duplication of the tests in the case of virtually all species.

It is a well-established fact that the amount of moisture remaining in the soil when the plant wilts beyond recovery is determined by the physical structure of the substratum. The object in making the wilting coefficient determinations, then, is principally to show (1) that certain species occupy quite different soil types, and (2) that the soil types (textures) are widely contrasted as shown by the notable difference in the wilting coefficients for the various species. For example, mountain bunch grass (*Festuca viridula*) does not wilt seriously in the soil in which it characteristically grows until the water content is reduced to between 7 and 9.5 per cent. This plant is adapted to coarser and less rich soils than is mountain onion (*Allium validum*), for example, which is confined to exceptionally black, mealy soils, and which wilts beyond recovery when the soil moisture content drops to between 14 and 16 per cent. Owing to the relatively small amount of moist soil found in mountain range lands, it is evident that a species like mountain onion would not occur nearly as abundantly as mountain bunch grass.

As a means of comparing habitat requirements, the species are grouped in three classes as follows:

Class A, plants of high moisture requirement—those inhabiting saturated soils, such as open marshes, wet meadows and bogs; class B, plants of medium moisture requirement—those inhabiting relatively heavy soils which are saturated during the early part of the season, but later contain a medium amount of moisture; and class C, plants of low moisture requirement—those occurring in well-drained lands, open glades, and exposed situations.

It will be observed that practically three-fourths of the most valuable forage species are dry-land plants. This fact is of high economic importance, since the major portion of the range lands are well drained and afford conditions favorable only to plants which are comparatively drought resistant.

It is noted that a few species fall under more than one head so far as concerns their habitat requirements—that is, they are not strictly

[1] A resumé of the potent climatic factors under which these tests were conducted was published in the Journal of Agricultural Research, Vol. III, No. 2, 1914, "Natural Revegetation of Range Lands Based upon Growth Requirements and Life History of the Vegetation," pp. 95–102.

confined to any one soil type. Such plants, however, do not afford nearly the amount of forage those do which are found generally in the more open habitat (usually referred to as drought-resistant plants), where the soil is not finely disintegrated, is less well supplied with organic material, and has a wilting coefficient notably lower.

A relatively small proportion of the range lands are wet throughout the growing season; while bogs, marshes, and the like almost invariably support a more luxuriant stand of vegetation than any other, the herbage usually lacks in two essentials—palatability and nutritiousness. Those who have observed stock as to their choice of forage have noticed that sheep avoid marshes and wet habitats to a marked degree; that cattle drift to the better drained lands for most of their feed; and horses, if unaccustomed to marsh vegetation, such, for example, as sedges and rushes, graze it eagerly for a couple of days, after which they will not remain on the succulent feed if any other is available. Campers and mountain workers have found that their pack and saddle animals can not do the work when feeding on marsh and bog vegetation that they can on drier feed. Also, stockmen have found that fat made on succulent feeds is not of a solid character and in the case of long drives to market or of shipment shrinkage is abnormally heavy.

LIFE HISTORY.

To aid the reader in comparing the different phases of growth, the time of seed maturity, and the viability of the seed crop produced by the various forage species discussed, the results are summarized in Table 3.

It will be seen that the time of the flowering period varies more widely than that of seed maturity. This is due primarily to the greater contrast between the moisture and temperature of the soil during spring than in late summer and autumn seasons. Growth, of course, starts more promptly and vigorously in the better drained and consequently warmer soils than in the moister and cooler situations. Owing to the more uniform physical conditions in a given life zone as the season advances, the seed maturing period is much more uniform and is completed in less time than that of flower-stalk production. All species and situations considered, the flower stalks are mainly produced between July 5 and August 10, and the seed matured between August 15 and September 1. While the time of flower-stalk production and period of seed maturity are influenced by the physical factors, even greater contrast is brought about by weakening of the vegetation due to overgrazing. Plants seriously weakened through abusive grazing are late in producing flower stalks and in maturing the seed. In extreme cases no flower stalks are produced, and, in general, such seed as is produced has little or no germinative power. Plants less seriously weakened pro-

F—550

BUTTERWEED (SENECIO TRIANGULARIS).

F–56Q

SMALL BUTTERWEED (SENECIO COLUMBIANUS).

duce a small amount of viable seed, while those which have not been injured send up their flower stalks early, mature the seed crop before killing frosts occur in the autumn, and produce fertile seed.

The data compiled relative to the life-history performances of the different forage species have made possible the adoption of what is known as the "deferred or rotation grazing system." This system provides for the deferment of grazing on an allotment until the seed crop has matured—the size of the area to be protected depending, of course, upon the time at which the bulk of the seed crop ripens. Subsequent to complete revegetation, the area is grazed relatively early, thereby providing for the protection of a similar area elsewhere on the allotment without in any way jeopardizing the grazing interests or by wasting any part of the annual forage crop during the time required for revegetation. When the entire allotment has been thoroughly restocked, each portion, subdivision or camp is restricted from grazing but once in every three or four years, thus allowing the plants to maintain a maximum vigor and to provide an occasional seed crop, which is essential to the maintenance of a permanent stand.

The details essential to revegetation by means of deferred and rotation grazing have been given in previous publications.

TABLE 2.—*Soil moisture requirements of native forage plants.*

Name of plant.		Soil-water content at time of excessive wilting.	Class.
Local.	Scientific.		
		Per cent.	
High huckleberry	*Vaccinium membranaceum*		
Mountain onion	*Allium validum*	14.0–16.0	
Slender reed-grass	*Cinna latifolia*	13.5–16.0	A.
Tall meadow-grass	*Panicularia nervata*	12.0–14.5	
Tall swamp sedge	*Carex exsiccata*	22.5–24.0	
Black hair-grass	*Deschampsia atropurpurea*	12.5–14.7	
False hellebore	*Veratrum viride*	11.0–14.5	
Fireweed	*Chamaenerion angustifolium*	8.2–11.5	
Fire willow	*Salix scouleriana*		
Porcupine grass	*Stipa occidentalis*	9.5–11.5	
Rush	*Juncus mertensianus*		
Rush	*Juncus orthophyllus*		B.
Small wild onion	*Allium fibrillum*		
Smooth wild rye	*Elymus glaucus*	7.5– 9.8	
Tufted hair-grass	*Deschampsia caespitosa*	11.5–14.5	
Wild celery	*Ligusticum oreganum*	8.0– 9.5	
Wild onion	*Allium platyphyllum*		
Wood rush	*Juncoides parviflorum*	10.0–12.5	
Butterweed	*Senecio triangularis*	11.5–14.0	
Coneflower	*Rudbeckia occidentalis*	16.0–18.5	A
Marsh pine grass	*Calamagrostis canadensis*	11.0–14.0	and
Mountain timothy	*Phleum alpinum*	14.0	B.
Sheep sedge	*Carex illota*	14.0	
Big bunch grass	*Agropyron spicatum*	5.5– 7.5	
Blue bunch grass	*Festuca idahoensis*		
Elk grass	*Carex geyeri*	6.5	
Geranium	*Geranium viscosissimum*		
Horsemint	*Agastache urticifolia*		
Little bluegrass	*Poa sandbergii*	6.5– 7.8	
Little needle grass	*Stipa minor*	9.2–11.5	
Mountain bunch grass	*Festuca viridula*	9.5 –7.0	
Mountain dandelion	*Agoseris glauca*	8.0–10.0	
Mountain June grass	*Koeleria cristata*	10.0–13.5	
Mountain wheat grass	*Agropyron violaceum*	6.0– 7.5	
Onion grass	*Melica bella*	6.3– 8.5	C.
Pine grass	*Calamagrostis suksdorfii*	5.5– 8.5	
Red bunch grass	*Agropyron flexuosum*		
Rush	*Juncus confusus*		
Rush	*Juncus parryi*	5.5– 7.0	
Soft cheat	*Bromus hordeaceus*	5.5	
Spiked trisetum	*Trisetum spicatum*	7.5– 9.5	
Short-awned brome grass	*Bromus marginatus*	5.5– 8.0	
Tall bluegrass	*Poa brachyglossa*		
White foxtail	*Sitanion velutinum*	6.0– 8.5	
Woolly weed	*Heracium cynoglossoides*	8.0–10.5	
Yarrow	*Achillea lanulosa*	10.0–12.3	
Alpine redtop	*Agrostis rossae*	7.0– 8.5	
Blue beardtongue	*Pentstemon procerus*	8.0–10.0	B
Skunkweed	*Polemonium pulcherrimum*	7.0–10.0	and
Slender hair-grass	*Deschampsia elongata*	8.5–15.0	C.
Wild buckwheat	*Polygonum phytolaccaefolium*	8.0–10.0	
Valerian	*Valeriana sitchensis*	7.0– 8.5	

TABLE 3.—*Time of flower-stalk production, time of seed maturity, and seed viability of the native forage plants.*

Name of plant.		Flower stalks produced.			Seeds matured.			Germination of seed.
Local.	Scientific.	1907	1908	1909	1907	1908	1909	
								Per cent.
Mountain bunch grass	*Festuca viridula*	July 5–Aug. 20	July 10–Aug. 25	July 3–Aug. 15	Aug. 18–Sept. 5	Aug. 15–Sept. 5	Aug. 5–Sept. 5	12.2
Blue bunch grass	*Festuca idahoensis*	June 10–July 25	June 5–July 15	June 20–Aug. 1	Aug. 15–Aug. 30	Aug. 10	July 20–Aug. 20	11.0–21.0
Porcupine grass	*Stipa occidentalis*	July 20–Aug. 5	July 15–Aug. 10	July 15–Aug. 10	Aug. 15–Aug. 25	Aug. 10–Aug. 25	Aug. 15–Aug. 30	27.0
Little needle grass	*Stipa minor*	July 25–Aug. 10	July 20–Aug. 15	do	Aug. 20–Aug. 31	Aug. 20–Sept. 10	Aug. 10–Sept.	
Mountain timothy	*Phleum alpinum*	July 15–July 25	July 15–Aug. 1	July 12–Aug. 1	Aug. 15	Aug. 20–Sept. 15	Aug. 15–Sept. 10	58.2–76.0
Slender reed-grass	*Cinna latifolia*	July 5–Aug. 5	July 10–Aug. 15	July 5–Aug. 10	Aug. 25–Sept. 10	Sept. 1–Sept. 20	Aug. 20–Sept. 10	79.0–86.8
Alpine redtop	*Agrostis rossae*	July 5–Aug. 15	July 10–Aug. 5	July 25–Aug. 15	Aug. 25–Sept. 5	Aug. 20–Sept. 15	Aug. 25–Sept. 30	29.0–41.0
Pine grass	*Calamagrostis suksdorfii*	July 20–Sept. 10	Aug. 1–Sept. 20	July 20–Aug. 30	Aug. 15	Aug. 10–Sept. 10	Aug. 10–Sept. 15	69.5
Marsh pine grass	*Calamagrostis canadensis*	June 25 to August 20, average.			August 1 to August 20, average.			59.5–86.5
Tufted hair-grass	*Deschampsia caespitosa*	July 25–Aug. 10	July 25–Aug. 15	July 15–Aug. 10	Sept. 1–Sept. 10	Sept. 15–Sept. 20	Aug. 25–Sept. 10	20.0–50.0
Slender hair-grass	*Deschampsia elongata*	July 15–Aug. 1	July 20–July 31	July 10–Aug. 1	August 5–25, average.			41.5–56–5
Black hair-grass	*Deschampsia atropurpurea*	July 20–Aug. 15	July 15–Aug. 25	July 15–Aug. 25	(1)	Sept. 1–Sept. 15	Sept. 1–Sept. 15	
Spiked trisetum	*Trisetum spicatum*	July 15–Aug. 1	July 10–Aug. 5	July 10–Aug. 10	Sept. 5–Sept. 10	(1)	Aug. 25–Sept. 15	19.5
Mountain June grass	*Koeleria cristata*	July 10–July 28	July 10–July 25	July 5–July 25	Aug. 20–Sept. 10	Aug. 15–Sept. 10	Aug. 10–Aug. 30	14.0–16.0
Onion grass	*Melica bella*	July 20–Aug. 10	July 15–Aug. 15	July 10–Aug. 15	Aug. 25 [2]	Aug. 20–Sept. 15	Aug. 25–Sept. 10	4.0
Mountain onion grass	*Melica spectabilis*	do	July 10–Aug. 15	July 10–Aug. 10	Aug. 25	Aug. 20–Sept. 10	Aug. 15–Sept. 5	
Little bluegrass	*Poa sandbergii*	July 10–Aug. 1	July 10–Aug. 10	July 5–Aug. 5	Aug. 10–Sept. 1	July 15–Aug. 20	July 20–Aug. 20	7.0–38.4
Tall bluegrass	*Poa brachyglossa*	June 1–July 1	June 1–July 10	June 1–July 15	Aug. 5–Aug. 20	Aug. 1–Aug. 20	Aug. 1–Aug. 25	
Short-awned bromegrass	*Bromus marginatus*	July 25–Aug. 10	July 25–Aug. 10	July 20–Aug. 10	Aug. 15–Sept. 10	Aug. 15–Sept. 15	Aug. 10–Sept. 10	38.0–58.0
Soft cheat	*Bromus hordeaceus*	By July 15, average.			By August 10, average.			63.3
Tall meadow grass	*Panicularia nervata*	July 15–Aug. 1	July 10–Aug. 1	July 10–Aug. 1	Not recorded	Aug. 25–Sept. 10	Aug. 20–Sept. 10	85.0
Big bunch grass	*Agropyron spicatum*	Aug. 1–Aug. 20	Aug. 10–Sept. 1	July 25–Sept. 1	Sept. 1	Aug 20	Aug. 15–Sept. 10	26.2
Mountain wheat grass	*Agropyron violaceum*	do	Aug. 5–Aug. 20	July 25–Aug. 15	(1)	Aug. 20–Sept. 1	Aug. 20–Sept. 10	85.5
Red bunch grass	*Agropyron flexuosum*	do	Aug. 10–Aug. 31	July 25–Aug. 20	(1)	Sept. 10	Aug. 25–Sept. 10	
Smooth wild rye	*Elymus glaucus*	July 5–Aug. 1	July 5–Aug. 5	July 1–Aug. 5	Aug. 15–Aug. 30	Aug. 1–Aug. 20	Aug. 5–Aug. 30	21.2
White foxtail	*Sitanion velutinum*	June 25–Aug. 1	June 20–Aug. 5	June 20–Aug. 1	Aug. 20	Aug. 20–Sept. 15	Aug. 15–Sept. 10	43.0–82.5
Tall swamp sedge	*Carex exsiccata*	June 20–July 15	June 20–July 10	June 20–July 20	Aug. 25–Sept. 5	Sept. 1–Sept. 15	Aug. 20–Sept. 15	15.2
Sheep sedge	*Carex illota*	July 15–August 5, average.			August 20 to September 10, average.			27.5
Elk grass	*Carex geyeri*	June 20–July 15	June 20–July 10	June 20–July 20	Aug. 1–Aug. 15	July 15–Aug. 5	Aug. 1–Aug. 20	6.0–32.0
Rush	*Juncus parryi*	July 10–Aug. 5	July 10–Aug. 10	July 5–Aug. 5	Aug. 25–Sept. 10	Aug. 25–Sept. 5	Aug. 25–Sept. 10	
Wood rush	*Juncoides parviflorum*	July 25–Aug. 10	July 25–Aug. 15	July 20–Aug. 15	Aug. 17–Sept. 1	Aug. 15–Aug. 30	Aug. 10–Aug. 30	7.5
Mountain onion	*Allium validum*	July 1–Aug. 5	July 5–Aug. 15	July 5–Aug. 15	Aug. 25	Aug. 25–Sept. 10	Aug. 20–Sept. 5	37.0
Small wild onion	*Allium fibrillum*	June 1–June 25	June 1–June 25	June 1–July 5	Aug. 1–Aug. 10	July 10–July 30	July 15–Aug. 10	
Wild onion	*Allium platyphyllum*	do	June 5–July 1	June 5–July 15	do	do	do	
False hellebore	*Veratrum viride*	Aug. 5–Sept. 1	Aug. 5–Aug. 31	July 25–Sept. 1	Sept. 1	Sept. 1	Aug. 25–Sept. 15	21.5–26.0
Fire willow	*Salix scouleriana*	June 1–June 20	June 5–June 15	June 1–June 15	(1)	(1)		
Wild buckwheat	*Polygonum phytolaccaefolium.*	July 20–Aug. 5	July 15–July 31	July 15–July 30	(1)	Aug. 1–Aug. 25	July 25–Aug. 15	3.0–13.5

[1] Practically no seeds reached full maturity.
[2] A blank following the date of seed maturity indicates that only a few seeds matured at the time specified, and the remainder of the seed crop never reached full development.

TABLE 3.—*Time of flower-stalk production, time of seed maturity, and seed viability of the native forage plants*—Continued.

Name of plant.		Flower stalks produced.			Seeds matured.			Germination of seed.
Local.	Scientific.	1907	1908	1909	1907	1908	1909	
								Per cent.
Geranium	*Geranium viscosissimum*	Not recorded	June 25–July 25	June 20–July 25	Not recorded	July 30–Aug. 15	July 25–Aug. 15	29.5
Fireweed	*Chamaenerion angustifolium.*	do	June 20–Aug. 1	June 25–Aug. 10	do	Aug. 1–Sept. 15	Aug. 10–Sept. 15	16.5–28.0
Wild celery	*Ligusticum oreganum*	July 20–Aug. 5	July 12–Aug. 5	July 10–Aug. 10	Aug. 25	Aug. 20–Sept. 10	Aug. 15–Sept. 1	2.0–11.5
Skunkweed	*Polemonium pulcherrimum*	Not recorded	July 10–Aug. 20	July 12–Aug. 15	Not recorded	Aug. 20–Sept. 10	Aug. 15–Sept. 5	32.5–41.5
High huckleberry	*Vaccinium membranaceum*	June 5–June 25	June 10–July 1	June 5–July 10	Aug. 1–Sept. 10	Aug. 5–Sept. 5	Aug. 5–Sept. 15	
Horsemint	*Agastache urticifolia*	July 10–Aug. 20	July 8–Aug. 20	July 15–Aug. 15	Aug. 25	Sept. 1–Sept. 15	Aug. 20–Sept. 5	16.0–28.5
Blue beardtongue	*Penstemon procerus*	Not recorded	July 10–Aug. 15	July 10–Aug. 5	Not recorded	Aug. 10–Sept. 1	Aug. 15–Aug. 30	18.5
Mountain elder	*Sambucus melanocarpa*	do	July 10–Aug. 5	July 15–Aug. 10	do	Aug. 20–Sept. 10	Aug. 25–Sept. 15	
Valerian	*Valeriana sitchensis*	July 15–Aug. 15	July 8–Aug. 10	July 5–Aug. 15	Aug. 20	do	do	21.5–26.0
Mountain dandelion	*Agoseris glauca*	July 20–Aug. 15	Aug. 10–Sept. 5	July 25–Aug. 20	Aug. 10	Aug. 10–Aug. 25	Aug. 10–Sept. 5	29.0–41.0
Woolly weed	*Hieracium cynoglossoides*	Not recorded	July 15–Aug. 20	July 20–Aug. 15	Not recorded	Aug. 25–Sept. 15	Aug. 25–Sept. 15	9.3–12.5
Coneflower	*Rudbeckia occidentalis*	July 10–Aug. 15	July 10–Aug. 20	July 15–Aug. 20	Aug. 25	Aug. 25–Sept. 20	Aug. 20–Sept. 5	11.0–21.5
Yarrow	*Achillea lanulosa*	June 10–Aug. 25	June 10–Sept. 10	June 10–Sept. 15	Sept. 1	Aug. 20	Aug. 20	16.5–90.0
Butterweed	*Senecio triangularis*	Aug. 1–Aug. 20	Aug. 1–Aug. 25	July 20–Aug. 20	Sept. 1–Sept. 10	Aug. 25	Aug. 20–Aug. 30	18.0–26.0

APPENDIX: PLAN OF STUDY.

In obtaining information on the individual forage species, consideration was given as far as possible to the following points:

1. Name of plant, both Latin and common.
2. Distribution.
   - *a*. Characteristic zone.
   - *b*. Most typical habitat; abundance and density of stand.
3. Usual plant associations and communities.
4. Habit of growth.
   - *a*. Annual or perennial.
   - *b*. Tufted growth, height growth, and character of herbage.
5. Character of root system.
   - *a*. Spreading fibrous root, or taproot with lateral rhizomes.
   - *b*. Depth of roots in soil.
6. Ecological requirements.
   - *a*. Soil and moisture preferences.
   - *b*. Drought resistance.
7. How flower stalks are sent up.
8. How fertilized.
9. When seeds are matured.
10. How and when seeds are disseminated.
11. Seed habits, strong or weak. Viability tests.
12. Period of germination.
13. Classes of stock which graze it.
14. Suitability for early or late grazing.
15. Palatability when green and when matured.
16. Time at which it is usually grazed.
17. Relative forage value.

Information on the points in the above outline was secured through investigation extending over four successive years. The actual ecological requirements of the various species could be determined only through physical-factor measurements.

An important factor affecting the distribution, and more particularly the succession of vegetation, is available soil moisture. Experiments showed that the greatest physiological activity is manifested at the time fertilization is taking place or immediately after the completion of the flower-stalk production but prior to a pronounced development of the seed.

The comparative ability of the various species to withstand drought was determined by ascertaining for each species the amount of moisture remaining in the soil when the plant had wilted to a point from which it could not recover. Unless pronounced wilting was actually in progress as a result of aerial and soil conditions, it was necessary to bring it about by cutting off the water supply from the plant. In making determinations in the field one of the methods used was as follows: The plants to be tested were dug up, with the roots undisturbed in their own soil, particular care being taken to prune off as little of the root system as possible. The block of soil

held together by the intertwining of the roots was wrapped in burlap for purposes of transfer and immediately placed upon suitably cut wire screen (see Plate I), which, when fitted and fastened together around the soil body in the form of a basket, was placed in the hole created by the digging of the plant. In this manner the plant was not subjected to too rapid drying and its normal functions were unimpaired. After the plant had fully recovered from any slight disturbance due to digging, it was elevated slightly in order to increase the rapidity of the drying process. The wire-basket method made the plant portable, a very desirable feature in field work since the plant could easily be removed from the field during showers and when in a wilted condition prior to soil sampling and placed under shelter—in this case in a carefully-placed 14-ounce canvas tent—and thus protected from direct effects of wind and sun when the specimen might recover its turgor if not wilted excessively.

The other method of ascertaining the water requirements was to dig away the soil on all sides of the plant, leaving in place the central core of soil supporting the roots, the size of which would depend upon the spreading habit of the root system (see Plate I, fig. 2). This method was used especially for certain species with deeply penetrating taproots, such as wild celery (*Ligusticum oreganum*) and wild buckwheat (*Polygonum phytolaccaefolium*). These, it was found, would not respond normally to the wire-basket method of treatment. The drying process brought about in this way, owing to the fact that the water supply was not wholly cut off from below, was slightly more gradual than in the case of the wire-basket method, but the results of the tests for species which did not have a distinct taproot, such as grasses, proved to be virtually the same as those secured for the same species by the wire-basket method. When the plant reached a condition of pronounced wilting and turgor could not be recovered, two representative soil samples were taken, weighed immediately to avoid possible discrepancy due to evaporation, placed in a soil-drying oven and subjected to a temperature not exceeding 212° F. for several hours until they were dry, then reweighed. The difference between the dry weight of the samples and the weight when taken at the time the plant was in a wilted condition represents the amount of moisture remaining in the soil at a time when the root hairs were unable, under the conditions, to absorb moisture rapidly enough to maintain the form of the plant and finally to recover its turgidity. The depth and location at which soil samples were taken were regulated by the depth of penetration and position of the roots. This operation was followed by protecting the specimen from the direct effect of sun and wind by placing a small tent shelter over it. In all cases the soil moisture figures given are based upon specimens which failed to recover their turgor, unless otherwise stated. All moisture require-

ment determinations of species were made from two to four weeks after the flower stalks began to show.

Since the character of the soil and the nature of the habitat play an important rôle in the amount of water the substratum may yield to the plant, the wilting of species was tested as nearly simultaneously and under as nearly the same topographic features as possible. The results therefore are comparable.

To ascertain the germination per cent of the seed crop, matured seeds were collected in the fall of each year for three years from typical situations, and germination tests were made in the seed-testing laboratory of the United States Department of Agriculture.

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